METALLURGIA

The British Journal of Metals
(INCORPORATING THE METALLURGICAL ENGINEER.)

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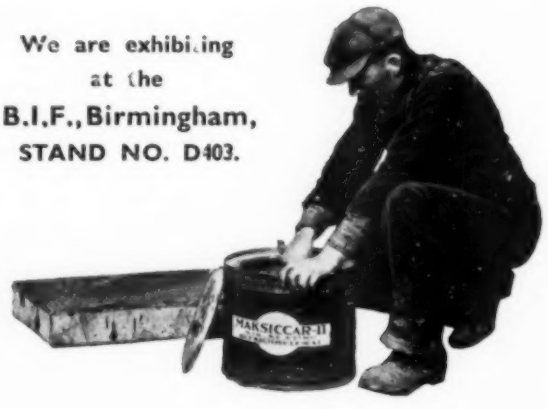

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METALLURGIA

THE BRITISH JOURNAL OF METALS.
INCORPORATING "THE METALLURGICAL ENGINEER".

FEBRUARY, 1937. VOL. XV., NO. 88.

Some Nickel Cast Irons in Engineering

Recent developments in cast-iron metallurgy have made available new types of alloy castings with greatly improved properties, and these new types of castings are finding new applications in all branches of engineering. Many of the more successful alloys contain nickel as a constituent, and brief reference to some of these alloy cast irons is made in this article.

CAST iron is undoubtedly one of the most important of the materials of construction employed in engineering to-day, not only on account of its relative cheapness and adaptability, but also because recent developments have resulted in greatly improved properties. Remarkable progress in the improvement of strength has been made by the introduction of alloys, by special methods of melting and preparation for castings, and by heat-treatment, and to-day iron castings are available having strength up to 25, or even 30, tons per square inch. One of the most successful of modern high-duty cast irons is that containing nickel, which has been developed under the name of "Ni-Tensyl."

During recent years the tendency has been to minimise the quantity of carbon present as graphite, with the object of developing high-duty cast iron, and to control the size and form of the graphite flakes so that they will be as fine and as widely dispersed as possible. In the production of Ni-Tensyl a cheap, low-carbon cast iron is used which will give white iron castings; this base iron is inoculated with nickel and silicon, as a result of which it yields grey iron castings, with the graphite in a finely dispersed form. This is a patented process.

The base iron recommended has the following analysis:

T.C.	Si.	Mn.	S.	P.
2·5–3·0	0·5–0·8	0·7–1·0	0·12 max.	0·2 max.

The inoculation treatment, which is carried out when the metal is molten, and shortly before the castings are poured, consists in adding sufficient nickel and silicon to give effective graphitisation, the amount depending upon the size of the casting being made. Satisfactory results are secured in most cases by bringing the silicon content up to 1·25% or 1·75%, and by adding about 1% or 2% of nickel.

The outstanding property of this alloy cast iron is its tensile strength, which usually reaches 25 tons per square inch. It is relatively hard, due to the fine and dense structure resulting from the low carbon content and inoculation treatment. Hardness values as high as 280 Brinell have frequently been obtained, yet the metal has proved easier to machine than ordinary cast iron. It is amenable to heat-treatment, and by applying a simple quenching and tempering operation, strength figures of 30 tons per square inch and over have been obtained repeatedly in commercial castings. In addition to high tensile strength the alloy shows remarkable resistance to impact. Some results obtained on test-bars, machined from bars cast $\frac{7}{8}$ in. diameter, are given in Table 1. The figures in each case are the average of two tests, the weight of blow being 0·481 ft./lb. on notched bars 13 mm. diameter.

Courtesy of Robey & Co., Ltd.,

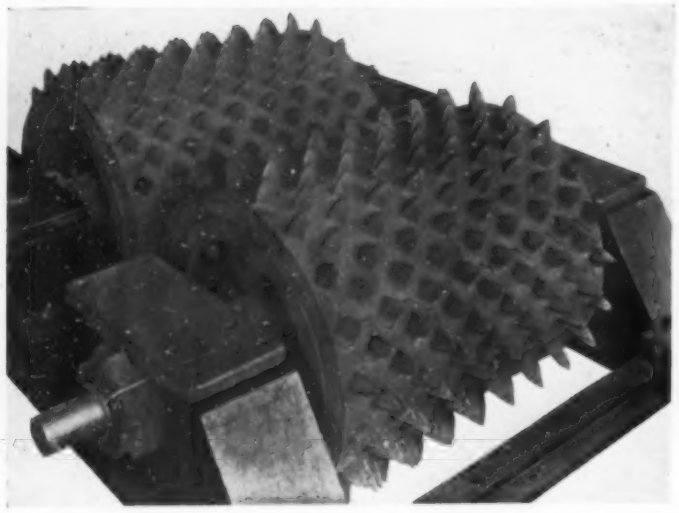
Diesel engine flywheel in Ni-Tensyl.

TABLE 1.—REPEATED IMPACT TESTS.

Material.	Actual transverse strength (T.R.S. Tons/Sq. In.	Approx. tensile strength Tons/Sq. in.	Repeated impact, blows to fracture.
Ordinary cast iron	23·0	11·0	32
Machinery cast iron	28·3	15·0	162
NI-TENSYL.			
As cast	36·8	23·0	1,838
Heat-treated to 302 Brinell	—	33·0	2,817

This new alloy cast iron is being used successfully for machinery castings of all types, in many cases as a substitute for steel. It has, for instance, been applied in the production of Diesel-engine flywheels, sugar-mill housings, crusher frames, and similar large castings, and the castings have been found to be uniform throughout and to fulfil completely the conditions specified.

An important high-strength application of this alloy is in dies for pressing or blanking sheet steel. It has been found, for instance, that an iron containing 2·7% to 2·9% carbon, and from 1·25% to 1·75% of both nickel and silicon, is particularly suitable in the cast condition for large and complicated dies, as well as for small dies used for drop-forging. In this condition it has a typical hardness of 230 Brinell, and a strength of 25 tons per square inch. For smaller dies the same iron, with the nickel content increased to 2·5% to 3·5%, may be heat-treated, by oil-



Segments of "Ni-Hard" cast iron fitted on coke crusher.

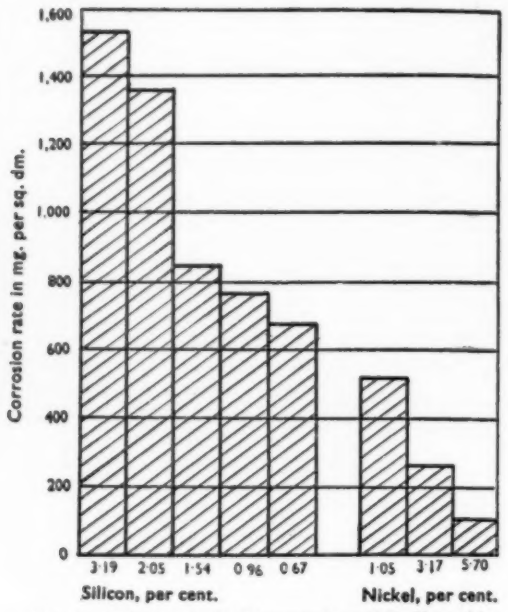


Fig. 1.—Diagram by E. Piwowarsky and P. Kötzschke, showing the corrosion of grey cast iron in 25% caustic soda solution at 230° C. after 15½ hours duration on test.

quenching from 850° C. and tempering at 350° C., to give a hardness of 400 Brinell and a tensile strength of 30 tons per square inch.

The use of high-duty cast irons for dies has economical advantages, because instead of using a complex design, involving many parts in different metals, in many cases it is possible to cast the whole die in one piece in such a way that, after machining, and with or without heat-treatment, the desired properties of strength and wear resistance can be obtained.

Many new types of alloy cast irons with greatly improved properties are being successfully applied in the various branches of the chemical industry, The types of greatest interest in this connection are the low-alloy irons and the new austenitic cast irons, such as Ni-Resist, which possess remarkable resistance to many types of corrosive media. Other types include low-alloy and austenitic irons, developed to combine corrosion-resistance with heat-resistance, and compositions which offer special resistance to the effects of erosion and abrasion.

Although small proportions of nickel give a definite improvement in the resistance of cast iron to attack by many corrosives, including alkalies and weak acids, under some conditions the alloy addition may not have any striking effect upon the inherent resistance of the metal in service. On the other hand, by the use of alloy cast iron certain other advantages can be gained which are of the greatest importance to chemical engineers. One of the chief of these advantages is the improvement in density and strength of the alloy castings. Another is the uniformity which results from the use of nickel.

It often happens that although a cast iron may have an adequate life in certain parts of the equipment, individual castings in other parts fail prematurely by reason of "segregation," which is revealed as porous and dirty patches in the metal. Such patches are prone to attack, and a good grade of alloy cast iron, substituted for ordinary iron, has often increased the life of the casting many times by conferring uniformity and ensuring the absence of these points of local weakness. In the case of caustic pots, for instance, the attack of alkali on a porous patch may mean premature ruin, although the casting, as a whole, may have suffered only slightly. The use of a suitable grade of alloy cast iron, containing 1% to 2% of nickel, has been proved to inhibit this segregation.

It is noteworthy that the addition of nickel to cast iron does itself definitely improve resistance to alkaline attack, quite apart from the question of localised failure due to segregation, as is shown in Fig. 1. Some manufacturers of chemical equipment use 3%, and even 5%, of nickel in the iron casting in order to obtain the maximum resistance in the low-alloy iron. Although a straight nickel cast iron is generally preferred for caustic service, chromium-nickel irons of low-silicon content, having the following compositions, are sometimes used :

C.	Si.	Ni.	Cr.	Mn.
3·30 ..	0·50 ..	2·00 ..	0·30 ..	0·50
3·30 ..	0·70 ..	1·50 ..	0·60 ..	0·50

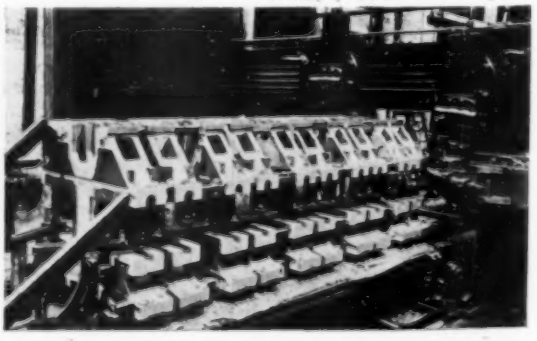
The addition of small proportions of nickel to cast iron not only improves the basic resistance of the metal to attack by alkalis, but is also advantageous in improving resistance to other types of corrosives, including weak hydrochloric acid and many other weak solutions met in the chemical and process industries.

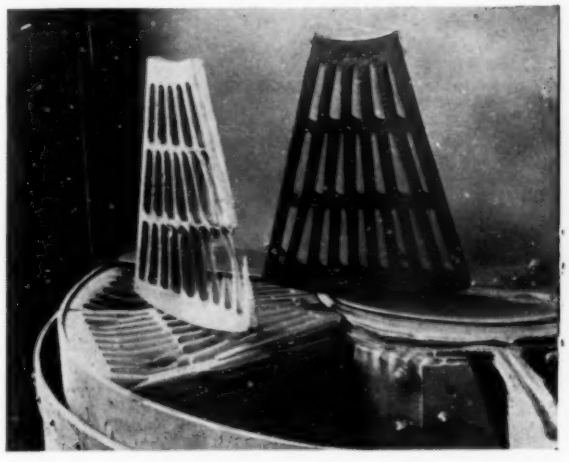
In many locations in chemical plant corrosion is inseparably associated with erosion, as, for example, where mixtures of liquids and solids have to be handled. In such cases the erosion caused by the solids may be the predominant factor, and the constant removals of any protective film on the castings may result in active corrosion proceeding continuously. Under these circumstances the various grades of hard and erosion-resistant alloy cast iron recently introduced are of interest. These include not only hard, grey irons, but irons containing such proportions of alloy additions that they are relatively soft and easily machined as cast, but after machining can be hardened by heat-treatment to give the required wear-resistance.

One of the most interesting types of cast iron which has recently been developed for erosion-resistance is "Ni-

Sugar mill headstocks in Ni-Tensyl, replacing cast steel.

Courtesy of Mirrlees Watson Co., Ltd.





This photograph shows the condition of plates used on rotating sand-blast table after 116 days under the blast. The plain iron plate (left) is badly worn, but the sand-cast "Ni-Hard" plate (right) shows no appreciable signs of wear.

Hard,"* a chilled or white cast iron alloyed with nickel and chromium to give a hardness as high as 800 Brinell, on account of which it is not machinable. This type of iron is readily adaptable for the manufacture of pumps and other types of equipment, and is used especially where gritty mixtures such as many slurries and effluents have to be handled. This alloy has a martenitic structure, and its composition lies within the following range :

C.	Si.	Ni.	Cr.	Mn.
2·75–3·6	0·50–0·8	4·40–4·6	1·40–1·6	0·7–1·2

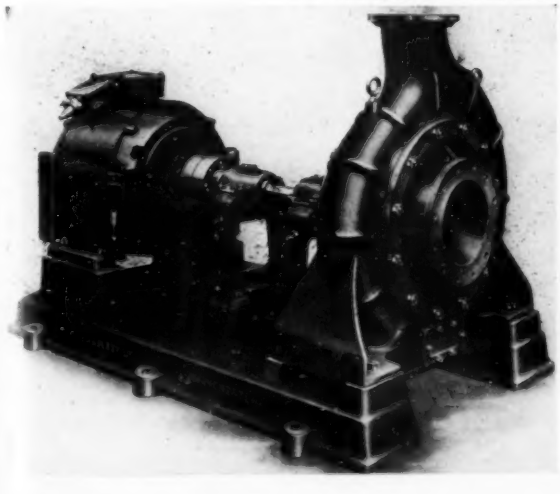
There are many instances where corrosion takes place in castings subjected to elevated temperatures, and to meet the severe conditions encountered it is often necessary to select an iron for its heat-resistance as a preliminary to obtaining an economic life in service. Under these circumstances heat-resisting nickel-chromium cast irons are available, but the service given by the austenitic cast iron is greatly superior. These latter cast irons represent one of the most important developments in cast iron as applied to chemical engineering.

It is now generally recognised that one of the common causes of failure in cast-iron equipment in chemical service is the infiltration of the chemicals through coarse graphite flakes, and, as pointed out earlier in this article, the life of the cast iron is increased by effecting a finer distribution of the graphite flakes, making them less continuous, and

*Covered by Brit. Pat. 279,414.

"Karntclog" stuff pump in which "Ni-Resist" cast iron is used for all castings when dealing with a paper stock containing 2% or more of solid matter.

Courtesy Mather & Platt, Ltd.



Courtesy of Rebey & Co., Ltd.

Roller end casting in "Ni-Resist" illustrating the fluidity of the metal and its suitability for thin section castings. Annealing at 950° C. for one hour has rendered the thin tangs malleable.

Courtesy of Sheepbridge Stokes Centrifugal Castings, Co. Ltd.

Nicrosilal regenerator box casting.

at the same time making the continuous phase, which will be predominant in amount, a single solid solution. Both of these conditions are met in the austenitic cast irons which have been developed in recent years. Two of these alloys, known as "Ni-Resist" and "Nicrosilal," are represented by the following compositions :

	C.	Si.	Ni.	Cr.	Mn.
Ni-Resist	2·7–3·2	1·0–2·0	14·0–17·0	2·50 max.	1·0–1·50
Nicrosilal	1·5–2·0	4·2–4·8	18·0	2·0	1·0

It will be noted that each has a high-nickel content, because this is essential in order to maintain austenite as a stable phase when the castings are cooled in the mould

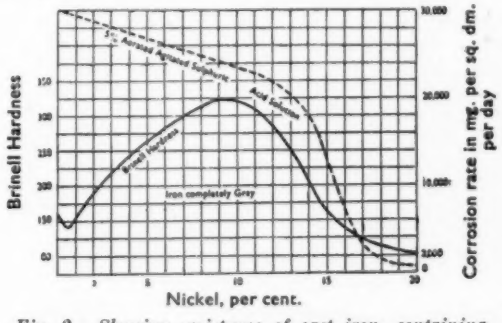

Brinell Hardness
Corrosion rate in mg. per sq. dm. per day
Nickel, per cent.
5% Aerated Agitated Sulphuric Acid Solution
Brinell Hardness
Iron completely Grey

Fig. 2.—Showing resistance of cast iron, containing varying percentages of nickel, to attack by 5% sulphuric acid solution.

The structural properties of these austenitic irons render them particularly resistant to corrosion from many chemical products. Some indication of this is given in Fig. 2, which shows the influence of nickel on the attack of cast iron by weak sulphuric acid. A study of this diagram shows that the austenitic irons possess a remarkable resistance.

It is interesting also that "Ni-Resist" combines corrosion-resistance with a very useful resistance to erosion, and for this reason it is used extensively where the combined effects of corrosion and erosion are encountered. Generally, however, the value of the austenitic irons lies in their resistance to heat and corrosion. The nickel, chromium, carbon and silicon combine their influences to produce a matrix that is but little affected by oxidation at high temperatures or by acid attack at low temperatures.

In order to facilitate the identification of the "Hiduminium" alloys with appropriate British Standard Specifications and Air Ministry D.T.D. Specifications, High Duty Alloys, Ltd., Buckingham Avenue, Trading Estate, Slough, Bucks., have compiled an index which should be inserted in their Data Sheet Folder. Copies of this index are available on application to High Duty Alloys, Ltd.

Canada's Base-Metal Production

CANADA produces four of the world's most indispensable industrial metals—nickel, copper, zinc and lead, each in enormous quantities. The concentration of these metals occurs in such richness that they can be produced more cheaply than in most competing countries, with the result that the demand for these metals has improved remarkably, and Canada is enjoying a state of industrial recovery. Her position as one of the world's outstanding metal-producing countries is emphasised when it is realised that she stands second in zinc, third in copper, and fourth in lead. Even more interesting is a consideration of Canada's total output of these base metals during the past year.

Copper

Copper production in 1936, at 414,137,000 lb., was some 5,000,000 lb. less than in 1935, but owing to the increase in the price of this industrial metal the value rose to $38,665,000, as compared with $32,311,960 in the preceding year. Copper-producing mines in Ontario showed an increase, but the output from Quebec, Manitoba, Saskatchewan and British Columbia was less. The Britannia mine is now the chief producer of copper in British Columbia, the Granby mine at Anyox having ceased operations in August, 1935. It has been announced, however, that the Granby Company will reopen their property at Copper Mountain during the coming year. This will mean a gain in the output of copper from British Columbia in 1937. Copper prices rose from an average of 8·6 cents. per lb. in January to 10·6 cents per lb. in November and the first half of December; the average for the year was 9·4354 cents per lb., as compared with an average of 7·8 cents per lb. in 1935. These are prices on the London market transposed to Canadian funds.

Nickel

Nickel production last year totalled 167,713,000 lb., valued at $43,471,000. An increase of 21% in quantity and 23% in value. Production is made up of electrolytic nickel, nickel oxide, and nickel in copper-nickel matte exported. The International Nickel Company of Canada, Ltd., produces electrolytic nickel and nickel in oxide in Canada, and also exports copper-nickel matte. Matte produced by Falconbridge Nickel Mines, Ltd., is exported to Norway for treatment. During the year a quantity of nickel-copper ore was shipped by the British Columbia Nickel Mines, Ltd., to Japan.

Zinc

The production last year of zinc, including refined zinc at Trail, British Columbia, and Flin Flon, Manitoba, and zinc in concentrates exported, totalled 326,916,000 lb., valued at $10,765,000, as against 320,649,859 lb., worth $9,936,908 in 1935, an increase of 2% in quantity and 8% in value. Concentrates were exported from the Sterling mine of Cape Breton, the Tetreault mine in Quebec, and from British Columbia. Prices of zinc improved towards the end of the year, the average for November being 3·55 cents per lb., and for the first two weeks of December 3·7 cents per lb. The average for the year on the London market and computed in Canadian funds was 3·29 cents per lb.

Lead

Lead production at 377,965,000 lb. constituted a record, and marked an increase of 9% over 1934, the previous record year, when the output totalled 346,376,575 lb. Canada's chief source of lead is the famous Sullivan mine at Kimberley, British Columbia. Concentrates are shipped 200 miles to Trail to be smelted, the mine and smelter being owned by the Consolidated Mining and Smelting Co., Ltd. Lead is also contained in the ores of the Britannia and Premier mines. These ores are exported for treatment. The Mayo camp, in the Yukon, shipped 2,533,447 lb. of lead in ores. Quebec production came from the Tetreault property, which was reopened in June, 1935, and Nova Scotia again entered the lists as a lead producer, as the Sterling mine in Cape Breton began the export of lead concentrates during the summer of 1936.

Lead prices showed a steady improvement. In January the price of lead in London, coverted to Canadian funds, averaged 3·413 cents per lb.; in September, 4 cents; in November, 4·7 cents, and during the first two weeks of December, 5·24 cents; the average price for the year being 3·87405 cents.

Cadmium

Cadmium output in Canada last year was a record. This metal is recovered at Trail, British Columbia, and at Flin Flon, Manitoba, as a by-product in the refining of zinc. This is the first recorded output of this metal by the Hudson Bay Mining and Smelting Co. Selenium and tellurium are produced at the Canadian non-ferrous metallurgical works, treating ores from Manitoba, Saskatchewan, Ontario and Quebec.

Forthcoming Meetings

ROYAL SOCIETY OF ARTS.

Feb. 24. "Alloys," by Professor W. L. Bragg, O.B.E., M.A., D.Sc., F.R.S.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Mar. 9. "Some Aspects of Metallic Corrosion," by U. R. Evans, M.A., D.Sc.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Mar. 4. "Corrosion," by U. R. Evans, M.A., D.Sc.

NORTH-EAST COAST SECTION.

Mar. 9. "Large Non-Ferrous Castings," by J. E. Newson, M.Met.

SCOTTISH SECTION.

Mar. 9. "Some Aspects of Metallic Corrosion," by U. R. Evans, M.A., D.Sc. (Joint Meeting with Institution of Engineers and Shipbuilders in Scotland.)

SHEFFIELD SECTION.

Mar. 12. "Some Recent Researches in Wire Drawing," by Professor F. C. Thompson, D.Met., M.Sc.

SWANSEA SECTION.

Mar. 16. "Some Trends in the Use of Tin in Modern Engineering Practice," by D. J. Macnaughtan.

MANCHESTER METALLURGICAL SOCIETY.

Mar. 3. "Corrosion," by W. H. Hatfield, D.Sc., F.R.S.

Mar. 17. "The Electric Bright Annealing of Metals," by A. G. Robiette, B.Sc.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Mar. 5. "Principles of Metallurgy," by J. G. Pearce, M.Sc.

EAST MIDLANDS BRANCH.

Feb. 20. "Cupola Practice," D. McLain, U.S.A., presented by T. Spiers.

LINCOLNSHIRE SECTION.

Feb. 27. "Steel Castings," by F. Cousans.

LANCASHIRE BRANCH.

Feb. 20. "A Small Oil-fired Rotary Furnace and Its Products," by E. W. Wynn.

Mar. 6. "Light Repetition Castings," by R. P. Layfield.

BURNLEY SECTION.

Mar. 9. "Cupola Practice," by J. Jackson.

LONDON BRANCH.

Mar. 3. Further Recommendations of the Costing Sub-Committee.

SCOTTISH BRANCH.

Mar. 13. Annual General Meeting. "Gates and Risers" on Grey Iron Castings, by J. Longden, and on Steel Castings, by A. D. Kirby.

FALKIRK SECTION.

Mar. 6. "Foundry Sands," by W. Y. Buchanan.

SHEFFIELD BRANCH.

Mar. 4. "The Manufacture of Iron and Steel Castings in Green Sand," by C. J. Dodswell, Ph.D., T. R. Walker, B.A., and F. Whitehouse.

WALES AND MONMOUTH BRANCH.

Feb. 27. "Non-Ferrous Metals," by C. A. Howe. Recommendations of the Non-Ferrous Sub-Committee for Two-leaded Gunmetals. (At Newport.)

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THE BRITISH JOURNAL OF METALS.
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Britain and World Trade

THE people of this country have reduced the modest virtue of self-depreciation to a fine art. Few are prepared to admit that trade is good; the highest position to which it rises is considered as being "not bad." But let us admit the truth, that Great Britain is enjoying a period of prosperity. Some firms, for instance, have orders booked sufficient to keep their works operating at capacity for the next year or two. So busy are some industries that doubts have been expressed regarding the need for the British Industries Fair this year. It should be realised, however, that this is the time when real efforts should be made to expand trade, and this Fair does help British manufacturers to sell to foreign buyers, and it is in this direction particularly that manufacturers should concentrate a part of their energies.

There is a prevailing impression in some business circles that British engineering is concentrating all its efforts in supplying the requirements of the defence departments, but this is not strictly accurate, and there are firms specialising in small tools and others who manfacture heavy steel works plant who, at the present time, are developing their Continental trade and have a considerable number of orders on their books from several Continental countries.

The present increased activity is largely due to the greater demands of the home market. Britain's share of the overseas trade is increasing, but the actual figures are disappointing. Many firms, with considerable foresight, have started new industrial ventures; most of them, however, are designed to produce articles for which a home-market demand is provided, probably because it is much easier to cater for home than overseas trade, but manufacturers should not lose sight of the fact that Britain must export to live. She is the greatest importer among the nations of the world, and to be economically sound these imports must be paid for with exports or by service.

The general situation as regards world trade is very complex, though there are significant signs of an easier position due to a general upward trend; but manufacturers, as well as Governments, must study the problem as a whole if a new basis is to be found for trade as satisfactory under present conditions as that which existed before the war. The exchange of money and commodities between nations constitutes the greatest of all problems of statecraft to-day, exceeding in magnitude even the so-called problem of peace. The economic issues between nations are those the peoples really care about, and solutions of them are the best route to peace.

The vital problems concerning world trade are dealt with in practice through the medium of tariff policies, commercial treaties and national monetary policies, and it would indeed be a magnificent conception to contemplate world-wide agreement on these profound questions. But the successive failure of world conferences makes statesmen and business men despair of reaching worth-while goals by such a route, in the present temper of civilised mankind and under present conditions. Bilateral action is found to be difficult enough. Multilateral action is at the moment generally felt to be impracticable.

With the restoration and maintenance of confidence there are indications of improvement in international trade, and Great Britain, with her pre-eminent position in world trade, may succeed through an ever-widening range of bilateral understandings in creating a volume of stable and reliable trade exchanges from which a wider solution, multilateral in practical effect, if not in form, may flow. By preserving the world-trading interests of Britain, and the reciprocal trade of countries making agreements with her, this country may best succeed not only in fulfilling her duty to herself, but in serving the world at large.

Overseas trade is probably the most urgent need of the world to-day, and while it is easy to refer to world trade in general terms, it is based upon all the business transactions carried through by individual firms in this country and elsewhere, and each manufacturer should seek to encourage the flow of individual transactions. He should be under no delusion as to the complicated nature of overseas trade, sometimes it is bilateral, generally triangular, and often much more complicated. For instance, to give a simple example, Australia sends wool to Japan; Japan pays by sending silk to America: the Americans send corn to Denmark, and Denmark sends bacon to England—that payment by Denmark being in part satisfaction of the Australian debt to Great Britain. But manufacturers should persist in their efforts to build up a flourishing export trade. Few people will doubt the wisdom and necessity of this policy when it is appreciated that the present increase in productive activity in Britain is due, in no small degree, to rearmament and domestic construction programmes.

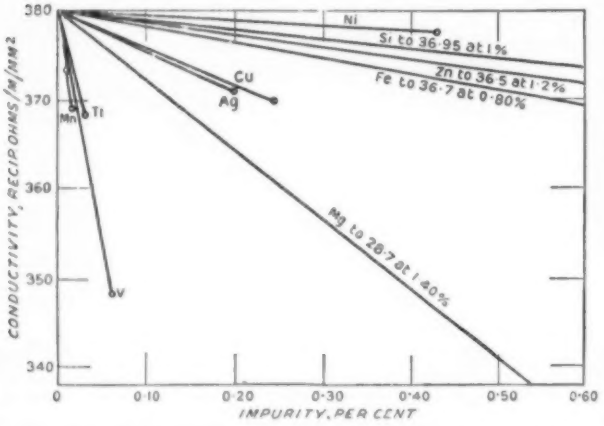
Mention was made earlier regarding the doubtful virtue of self-depreciation by the people of this country; but there is another type of modesty, which is all too prevalent, that of depreciating British manufacturers, especially in connection with overseas trade. Here, again, let us admit the truth that manufacturers in this country still lead the world for most of the articles that are made to stand the test of reliability. It will probably surprise those who decry the British manufacturer that, in the trade reports made to foreign Governments by their Consular officers, a frequent theme is the excellence of the goods, the service, the business methods and the enterprise of the British manufacturer, supplemented by a strong recommendation that the nationals of the foreign countries offering competition should take note, copy and emulate.

It is not suggested that in no case are the trading methods and services of British manufacturers capable of improvement. No nation has a monopoly of manufacturing and trading efficiency, but the British record in these respects is very high; the prerequisites of successful competition in overseas markets, however, must ever be kept in mind. Any manufacturer contemplating a particular market for his product should naturally familiarise himself with the needs of that market, and in his preliminary survey he could not do better than communicate with the Department of Overseas Trade, where a wealth of information is available. The British Industries Fair is organised by this Department, and this year's Fair, as with those previously held, constitutes a new drive for world trade. It provides a means of making direct contact with potential buyers from overseas, and of showing that the products of British industry in regard to quality, workmanship and cost are not exceeded by any other country.

The Electrical Conductivity of Aluminium

IT is a well-known fact that even small metallic additions increase the resistivity of metals. Therefore, the conductivity of a high purity metal is higher than the conductivity of the same metal in the commercial state.

In employing aluminium for electrical conductors only commercial grades can be used from an economical point of view, though it is advisable, of course, that this material is of the highest purity available in commercial grades. The accurate knowledge of the effect on the electrical resistivity of those elements likely to be introduced into the metal during its manufacture is, therefore, of utmost interest. This knowledge would make it possible to calculate the approximate conductivity of a sample from the chemical analysis alone. Furthermore, this knowledge could induce researches directed towards the elimination of the most harmful of those elements.



Mean decrease of conductivity in alloys of aluminium as a function of the content of alloying element added.

A considerable step towards this aim is a French investigation on the influence of small metallic additions carried out on super-purity aluminium made by the process of the Compagnie Alais, Froges et Camargue. The purity of this material exceeds 99·99% and enabled the elimination of the complications due to the interaction between added elements and incidental impurities. The investigation was not limited to those additions likely to be met with in practice, but included the effect of silver, gold and gallium in order to find out if there was any physical law determining the effect of additions.

The conductivity of 99·997% aluminium was found to be 65·45% of the conductivity of copper. Attention may be drawn to the fact that this figure is the highest ever recorded for aluminium. Samples of a somewhat lower purity gave the following figures (in percentage of the conductivity of copper): 99·991% aluminium, 65·35; 99·97% aluminium, 64·90.

The mean decrease of conductivity in aluminium as a function of the content of added elements is shown in the accompanying diagram. Comparing the influence of different elements, it is possible to distinguish three groups: (1) gold, gallium, nickel, silicon, iron and zinc have little effect; (2) copper, silver and magnesium have rather more effect; and (3) titanium, vanadium, manganese and chromium exert a considerable effect.

In spite of the precautions taken in preparing the samples and carrying out the tests no physical law could be determined governing the influence of alloying elements on the conductivity of aluminium.

The Soviet Novo-Tula Metallurgical Corporation is building a second blast-furnace in the Moscow province with a throughput of 800 tons per day. This brings the number of blast-furnaces in Russia up to 119.

Non-Ferrous Tube for Domestic Purposes

SMALL but not unimportant branches of the steel- and lead-tube trades will undoubtedly be affected by the issue of the British Standard Specification with regard to materials to be used in arranging future domestic water, heating and the like services. The specifications call for supplies of copper-tube of 0·35 arsenical properties. An analysis which, on account of its resistance to corrosion, brings it into line with that governing the manufacture of copper locomotive tubes generally recognised as the Midland Railway specification, where the arsenical contents are specified as within the limits of 0·35 to 0·55. The new specification will in all probability make a demand by copper-tube manufacturers for supplies of clean Midland loco. tubes in boilers of locomotives due for retubing, which will be redrawn into standard diameters and gauges in keeping with the new British Standard Specification.

The value of the trade in domestic tubes supply is recognised by lead- and steel-tube makers, who with the market at their disposal, making the opening-up of new fields unnecessary, have under consideration the extending of, or utilisation of, existing plant to cope with this new development. That there is a large demand will be realised by interested parties when a survey is made of the tubes used up in the large modern hotels, institutions of all kinds, and even the modern domestic house. The actual demands have led most of the manufacturers of non-ferrous tubes to realise its importance, and to include supplies in their speciality lines of the trade.

Anhydrite from Canada

THE use of anhydrite in England for the manufacture of sulphuric acid, ammonium sulphate, and special plasters is rapidly increasing. Canada is fortunate in having extensive deposits of this material favourably situated for commercial exploitation, the material from which has been proven by tests carried out by the Department of Mines, to be of excellent grade for these purposes.

Procedure Handbook of Arc Welding

PROGRESS in electric welding has made such rapid strides that the fourth edition of this handbook is fully justified. Designed in the first place to present, in a convenient form for ready reference, the basic information on arc welding, this book includes not only a complete description of the arc welding process in its various forms, but also the essential data for its use in welding various types of steels, iron and non-ferrous metals. What one may expect from welds is discussed in a section dealing with the structure and properties of weld metal. Accumulated information of value to the arc welding user has been incorporated in this edition, which is probably the most comprehensive book of its kind available.

This issue includes data on the characteristics of the welding generator, selection of types of joint, insurance, welding codes, arc cutting, polarity of welding current, horizontal welds, sheet-metal welding, effect of electrode size on welding cost, methods of testing weld metals, 4–6 chromium steel, Monel metal, principles of surfacing by welding, plate girders, etc., while new applications of arc welding are given in the manufacture or construction of parts in practically all industries.

This well-illustrated book, containing about 800 pages, will be invaluable to welders, welding supervisers, and foremen; in addition it will be especially valuable to designers, inspectors and those controlling welders, because there does not seem to be any important aspect of arc welding which has been omitted.

Published by LINCOLN ELECTRIC CO., LTD., Welwyn Garden City, Herts., England. Price, 8s. 6d. net.

Analytical Control of Chromium-plating Solutions

By E. E. HALLS.

Chromium-plating is applied with a purpose and to fulfil an important role and specific functions of the finish, cost of production, peculiarities of the process, are factors which stress the need for analytical control of the operation if success is commercially to be achieved.

CHROMIUM electro-deposition has assumed a position of first rank among plating processes, firstly because in conjunction with heavy nickel-plate underlays it makes it possible to produce excellent rust-proofing coatings on iron or steel for rigorous service conditions, and secondly, because it possesses and retains an attractive lustre of great decorative value. These two qualities together stamp chromium-plate as a utility finish of wide industrial possibilities. Again, it has been established widely for producing wear-resisting coatings on tools, gauges, and moving elements, as well as for repairing similar items by build-up when they have become worn. Chromium-plating, therefore, in each of its applications is applied with a purpose and an important role to fulfil. It is not an inexpensive finish, not only because the chromium-plating process proper employs an expensive chemical and high-current density, but also because of the heavy nickel underlay, and usually grinding and polishing operations, associated with the protective-decorative type of deposit, and of the heavy deposits demanded for toolwork. Again, a non-regenerative electrolyte with inert anodes is used, while cathode efficiency is very low. Consequently, specific functions of the finish, cost of production, peculiarities of the process, all these factors stress the need for analytical control of the operation if success is commercially to be achieved.

The electrolyte almost universally employed is a simple one—pure chromic acid, a little sulphuric acid, and distilled water. Sometimes chromic sulphate replaces the sulphuric acid, and occasionally special addition agents are employed. In operation, the solution becomes contaminated with iron from the iron container or from iron anodes, if such are employed. Also, during electrolysis chromic acid becomes reduced to trivalent chromium. Analysis, therefore, not only has to control additions of chromic acid to compensate for the chromium deposited at the cathode, and to maintain within narrow limits that important ratio of chromic acid to sulphuric acid, but also to reveal when excessive iron or chromium accumulate as dichromates. While specific gravity observations are useful when these first items alone are involved, they are negatived if the last items mount to appreciable values.

Analysis must thus provide the following data :—

1. Total chromic acid content.
2. Sulphuric acid content.
3. Trivalent iron and chromium (present probably as dichromates).

There are several methods of evaluating these quantities, and alternatives are only given where justified.

Stock Solution for Analysis

From a representative sample of the plating solution, a 25 cc. portion is taken, diluted to exactly 1,000 cc. with distilled water, and thoroughly shaken. If necessary, it is filtered, rejecting the first 20 cc. of the filtrate.

1. TOTAL CHROMIC ACID CONTENT.

METHOD A.

Method A is preferred for simplicity and clarity of end-point. The presence of ferric iron may interfere, but the quantity of this element present, compared with the chromic acid content, is so small that it presents no serious objection to the method.

To 25 cc. of the stock solution, 2 cc. to 3 cc. of concentrated hydrochloric acid and 4 to 5 grms. of potassium iodide are added. The mixture is diluted to 500–600 cc. with cold distilled water, and titrated with N/10 sodium thiosulphate solution. A few cc. of 0·5% starch solution is used as indicator towards the end-point.

1 cc. of N/10 sodium thiosulphate solution = 0·003334 grms. of chromic acid CrO_3. If "a" cc. of N/10 sodium thiosulphate are required for the titration of 25 cc. of stock solution, then chromic acid (CrO_3) content of plating solution = 0·854a oz.-gal.

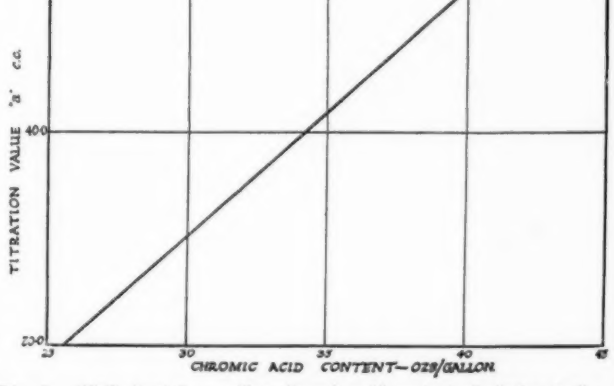


Fig. 1.—Wall chart for reading chromic-acid content of plating bath from analysis value "a."

METHOD B.

An accurate alternative utilises the following solutions :—

(*a*) N/10 ferrous ammonium sulphate, prepared from 40 grms. of the pure salt and 75 cc. concentrated sulphuric acid per litre.

(*b*) N/10 potassium permanganate prepared from 3·2 grms. of the pure salt per litre ; and

(*c*) N/10 potassium dichromate, for standardising (*a*) and (*b*), prepared from exactly 4·903 grms. of pure potassium dichromate per litre.

Standardisation of Reagents.—Solution (*a*) and (*b*) are standardised against the N/10 potassium dichromate solution, and then adjusted with distilled water to exactly N/10, as follows :—

25 cc. of the ferrous solution (*a*) are diluted to 250–300 cc. with distilled water, 24 cc. sulphuric acid added, and titration made with the potassium permanganate solution (*b*) to a persistent pink colouration as end-point in the usual manner. This evaluates the permanganate in terms of the ferrous solution, which is then checked against the dichromate.

25 cc. of N/10 potassium dichromate solution (*c*) is diluted to 250–300 cc. with distilled water, 25 cc. sulphuric acid added, and the mixture cooled. 50 cc. of the ferrous solution (*c*) is added, and the excess of the latter back-titrated with the potassium permanganate solution (*b*). The pink colouration of the end-point is a little masked by the colour of the

solution, but readily detected. A colour correction for the small error, due to the volume of permanganate required to obliterate the colour of chromium and ferric salts in the solution may be determined if desired in the following manner :—

Boil the solution at the end of the titration to destroy the slight excess of permanganate which causes the error. Cool, and again titrate to the same end-point. The volume of permanganate added is the correction to be subtracted from the previous titration.

Titration of the Stock Solution.—25 cc. of the stock solution is diluted to 250–300 cc., 25 cc. of sulphuric acid added, and the mixture cooled. Excess of the N/10 ferrous solution is run in from a burette, sufficiency being shown by a distinct colour change to green. 50 cc. usually suffices. The excess is back-titrated with N/10 permanganate solution.

1 cc. N/10 ferrous solution = 0·003334 grms. of chromic acid (CrO_3). Hence, if "*b*" cc. of N/10 ferrous solution, and "*c*" cc. of N/10 permanganate solution are employed for the titration of 25 cc. of stock solution, then chromic acid (CrO_3) content of plating solution = 0·854 (*b*–*c*) oz.-gal.

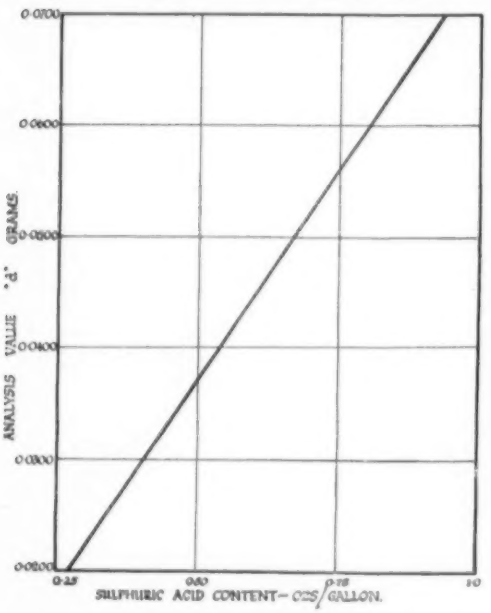


Fig. 2.—Wall chart for reading sulphuric acid content of plating bath from analysis value "d."

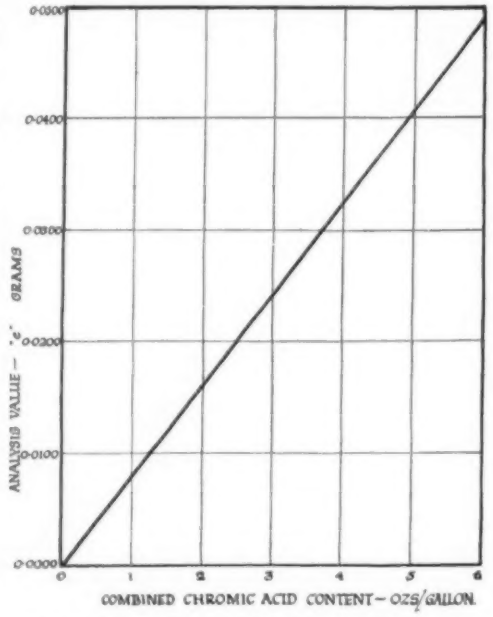


Fig. 3.—Wall chart for reading combined chromic-acid content of plating bath from analysis value "e."

2. Sulphuric Acid Content.

This must be estimated gravimetrically as barium sulphate.

To 200 cc. of the stock solution, 10 cc. of concentrated hydrochloric acid and 10 cc. of alcohol are added ; 64 O.P. industrial methylated spirit may replace the latter, but it should be checked to ensure it is free from sulphur. The mixture is cautiously and gently boiled to complete the reduction of chromic acid to chromium salts, and then evaporated to about 50 cc. If necessary, the solution is filtered, the residue washed and discarded, the washings being added to the filtrate.

The solution is diluted to about 300 cc. and brought to the boil. A slight excess of a hot solution of 10% barium chloride is added, and the solution simmered for half an hour. It is allowed to stand for at least three hours, and preferably overnight. The precipitate of barium sulphate is then filtered and thoroughly washed with hot water. It may be ignited wet in a tared silica crucible and weighed as barium sulphate, $BaSO_4$. If the weight of the latter is "*d*" grms., derived from 200 cc. of stock solution, then :—

Sulphuric acid (H_2SO_4) content of plating solution = 13·44 (*d*) oz.-gal.

3. Trivalent Iron and Chromium.

Information upon the extent to which iron and chromium salts exist in solution (they are there probably as dichromates) can only be obtained by their separate estimation, but the extent to which they depress the effective chromic acid content can be obtained by determining the two together as oxides. While this is an approximation, the error introduced is small and negligible for practical purposes, the equivalents being very close (Fe = 18·6, Cr = 17·3) or ferric oxide containing 69·94% iron, and chromic oxide 68·42% chromium.

(*a*) *Trivalent Iron plus Trivalent Chromium.*—200 cc. of the stock solution diluted to about 400 cc. with distilled water is heated short of boiling, and a slight excess of strong ammonia gradually added with continuous stirring. The solution is simmered till only a slight smell of ammonia is apparent, because chromium hydroxide is slightly soluble in excess of this reagent. The precipitate, a mixture of reddish-brown ferric hydroxide and green chromic hydroxide, is filtered and washed thoroughly with hot water. It is ignited wet in a tared silica crucible and weighed as $Fe_2O_3 + Cr_2O_3$. If "*e*" grms. is the weight of mixed oxides from 200 cc. of plating solution, then :—

Iron plus chromium dichromates in plating solution = 155 (*e*) oz.-gal. and combined chromic acid = 123 (*e*) oz.-gal.

(*Note.* — 159·6 grms. and 152 grms. respectively of Fe_2O_3 and Cr_2O_3 combine with 600 grms. (CrO_3) to yield the dichromates).

When separate information is required on the quantities of ferric and chromic salts present, the filtered and washed precipitate of mixed hydroxides obtained above is treated as follows :—

(*b*) *Trivalent Iron.*—The mixed hydroxides of iron and chromium after thorough washing are redissolved in the minimum amount of hot 50/50 hydrochloric acid, the filter being thoroughly washed, and filtrate and washings are combined. After cooling, a slight excess of sodium peroxide is added. This neutralises excess acid, precipitates iron as ferric oxide, and converts chromic chloride to sodium chromate. The solution is diluted to 300–400 cc., boiled to decompose excess peroxide, and then the ferric oxide is filtered off and washed. Combined filtrate and washings are reserved for the estimation of chromium.

It is difficult to wash soda alkali from ferric oxide completely, so it is deemed more rapid to redissolve the residue on the filter in hot 50/50 hydrochloric acid. The filter is washed with hot water, and the combined washings and filtrate precipitated hot with excess ammonia. The precipitate of ferric oxide can be filtered immediately, washed, and ignited wet in a weighed silica crucible. If "*f*" grms. of Fe_2O_3 are obtained from 200 cc. of stock solution, then :

Iron content, expressed as ferric oxide (Fe_2O_3) of plating solution = 32 (*f*) oz.-gal.

(*c*) *Trivalent Chromium.*—The solution containing chromium as sodium chromate, reserved in (*b*) is acidified

with hydrochloric acid and reduced to green chromic chloride by the passage of a stream of sulphur dioxide. Excess of the latter is expelled by boiling, and chromium precipitated from the hot solution by a slight excess of ammonia. The chromium hydroxide is filtered off, washed thoroughly, and ignited wet in a weighed silica crucible. It is weighed as chromic oxide (Cr_2O_3). If "*g*" grms. of Cr_2O_3 are obtained from 200 cc. of stock solution, then :—

Chromium present in plating solution as trivalent chromium, and expressed as chromic oxide (Cr_2O_3) = 32 (*g*) oz.-gal.

The frequency of analysis depends entirely upon local conditions, such as capacity of plant, continuity of operation, class and variety of work, and so on. Daily analyses for total chromic acid and for sulphuric acid contents, and a weekly determination of trivalent iron plus trivalent chromium is a typical practice. The separate estimation of ferric and chromic salts is less frequently made.

Finally, from the analytical values it is convenient in routine work to read the corresponding "ounces per gallon" equivalents from large-scale wall charts. Three typical graphs of this type are given in Figs. Nos. 1, 2, and 3 for total chromic acid content, sulphuric acid content, and combined chromic acid content, respectively.

Silver-Copper-Silicon Alloys

Results are given of an investigation on the physical and electrical properties during ageing of one of the ternary alloys of silver.

CONSIDERABLE work has been done on the binary system of copper and silver, but less information is available on the ternary alloys. To add to the information concerning the physical and electrical properties during ageing of one of the ternary alloys of silver, an investigation was carried out by T. C. Jarrett,* and in general it was found that, although in the binary system good electrical properties and good physical properties may go together, in the ternary system with silicon, a sacrifice of some of these good properties is necessary.

The various tests were made on alloys of the following composition :—

Alloy.	Silver. %	Copper. %	Silicon. %
Coin Silver	90·00	10·00	0·00
Alloy C	92·14	6·99	0·87
Alloy D	96·52	3·16	0·32
Alloy E	98·00	1·86	0·14

In the above analyses the silver is estimated by difference. The pure silver used in making the alloys was taken as having 100% electrical conductivity and coin silver was used as a means of comparison for both hardness and electrical conductivity of the three alloys. The alloys were melted and remelted in an induction furnace in order to ensure uniformity. The test pieces for ageing were 1 in. × $\frac{1}{2}$ in. × $\frac{1}{8}$ in., while those for electrical conductivity were 0·125 in. in diameter and were drawn through diamond dies to ensure a uniform diameter.

The increase of hardness with time at temperatures of 100°, 200°, 300° and 400° C. shows that at 100° C. the increase of hardness with time is very slow and that the maximum hardness does not approach that obtained at the other temperatures. This fact is specially noticeable in the coin silver, and in alloys C and D, but in alloy E the maximum hardness obtained at 100° C. is equal to that attained at 200° C. The rate of increase of hardness at 100° C. in the three ternary alloys increases as the amount of the intermetallic compound, probably Cu_3Si, decreases. Although the rate of increase of hardness is not as rapid at 200° C. as in the case of the higher temperatures, the alloys aged at 200° C. retain their hardness after a period of 144 hours, and this does not hold with temperatures above 200° C. At temperatures of 300° and 400° C., the time at which maximum hardness occurs is about the same. The decrease in hardness with time, however, is greater at 400° C., and the final decrease of hardness also occurs at this temperature.

The initial hardness after quenching is lower with decreasing amounts of the intermetallic compound present, and the actual final hardness obtained is about the same in all the ternary alloys tested. That the ageing is not due to the intermetallic compound but to copper is considered, since copper-silver alloys are known to age without silicon being present. It is shown, however, that in silicon-free alloys of low copper content, as the copper decreases, the rate of increase of hardness becomes less. In the case of a 2% silver-copper alloy no increase of hardness is noticed, while in alloy E, which contains 2% of the intermetallic compound a hardness equal to that of coin silver is obtained, and this appears to indicate that the hardness produced in the silver-rich alloys is due to the precipitation of the intermetallic compound.

The alloys were quenched from 700° C. and worked by the Brinell method, using a 500-kilogs. load to produce the desired amount of cold work. After such work, ageing was carried out at room temperature and at 300° C., but no appreciable change was found to occur in the hardness of any of the alloys. Tensile tests were carried out on the alloys in their fully annealed condition, after quenching in water from 700° C., and after quenching in water from the same temperature, and fully ageing for one hour at 300° C. The results of such tests showed the tensile strength to increase with the amount of intermetallic compound present, and the elongation and reduction of area to decrease.

In the electrical conductivity tests, a Kelvin double bridge was employed, and test-pieces 6 in. long × 0·125 in. diameter. The test specimens were treated the same as those used in the ageing tests, in that they were all made age hardenable by quenching from 700° C. in water and aged at 100°, 200°, 300° and 400° C. In all cases the conductivity increases as time and temperature of ageing increases. In coin silver no increase of conductivity takes place at 100° C., and not until after some 40 hours at 200° C. does any noticeable change occur. In the other alloys, there is a slow increase of conductivity at 100° C., comparable with the change in hardness, and although the hardness continued to drop with time at the higher temperatures the conductivity increased. The conductivity increases with temperature as the amount of the compound decreases, and this corresponds to similar results obtained from ageing tests in that the maximum hardness is produced in the alloys, where there is the least amount of intermetallic compound present.

Micro-examination of the three ternary alloys after quenching in water from 700° C. show considerable amounts of the intermetallic compound. It was first thought that the alloy itself or the compound in a particular alloy was actually molten when quenched, due to the continuous network of the compound present, but after further investigation this proved not to be the case. In the as-cast condition it was noticed that large quantities of the compound were present, and in all probability it was impossible to get this excess back into complete solution. In view of the fact that there is still an excess of the compound present the alloys upon heat treatment showed great increases in hardness and electrical conductivity. It was impossible to detect any changes in the micro-structure after slow cooling or ageing, other than in the as-quenched samples.

* *Metals and Alloys*, 1936. Vol. 7. PP. 309–313.

Controlled Grain Size in Steels

THE above subject was recently discussed at a joint meeting of the Iron and Steel Institute and the Staffordshire Iron and Steel Institute. The discussion was based on the paper presented to the Autumn (1936) meeting of the Iron and Steel Institute, by Dr. T. Swinden and Mr. G. R. Bolsover, F.Inst.P.

Dr. Swinden introduced the subject, and explained that the grain size defined in the original paper was that obtained by the method defined by McQuaid and Ehn in America. It consisted of case-hardening the sample at 927° C., and measuring grain size either direct or by comparison with a standard chart, from which a grain size number was allotted. The paper described the results obtained on a series of steels, in which the only variable, was grain size. The salient results were that the finer grain steel had slightly lower strength, slightly greater ductility and greatly increased toughness. Further, fine grain steels were less susceptible to the various types of brittleness. He considered as distinctly misleading the statement made some time ago that "it does not follow that such a fine grain steel will have a fine grain size when drop-stamped or forged, as some people seem fondly to imagine." The standard conditions laid down for determining grain size were arbitrary, the temperature not necessarily representing either forging temperatures or heat-treatment temperatures, but the essential fact to realise was that the evidence obtained by this method of determining inherent grain size could be correlated to definite and important differences in the behaviour of the steel when manipulated and heat treated in an orthodox manner.

What were the disadvantages of fine grain steel? There was some evidence to show that fine grain steel was not so readily machinable under certain conditions. The user must, therefore, decide whether the advantages to be gained were such as to merit, if necessary, a change in machining conditions to suit this particular type of steel. It was, however, surely desirable, accepting that a difference existed, that there should be applied a control of grain size. It was recognised that fine grain steel did not possess the same depth of hardening as coarse grain steel, but most of the work that had been done in emphasis of this point related to high carbon steels. It was shown in the paper that, as regards lower carbon steels, this did not mean that the enhanced properties of fine grain steel were not obtained in the centre of comparatively large masses of such steels. The paper did not attempt to deal with the theories underlying control of grain size, but the authors thought that the degree of oxidation was the fundamental factor. Several theories had been advanced in previous discussion, and he thought it very important that the investigation should continue until a completely acceptable theory was evolved. They must arrive at a correct hypothesis as to why two steels, otherwise exactly similar, should behave in widely different manners when reheated to certain temperatures and possess such different properties when produced and heat treated according to accepted production methods.

The discussion following Dr. Swinden's remarks resolved itself into a series of questions, to which Dr. Swinden replied at length. Referring to an opinion expressed by Mr. T. G. Bamford, Dr. Swinden said he did not accept the criticism that the title of the paper could have been more explicit, and he considered that the title implied what was intended. He thought the term "grain size" was incapable of misleading anyone, and that, although he had referred to the advantages and disadvantages of fine grain steel, he could see no disadvantage whatever in using controlled grain size steel. Reactivity was probably a factor, but not the whole story. They were now endeavouring by means of X-rays to learn more of the fundamental structure of metals, in the hope that they could predict the properties that would be possessed by unknown alloys, and predetermine composition.

With reference to the question of temperbrittleness, the paper explained that fine grain steel did not inhibit temper brittleness in steels otherwise susceptible, but that the degree of embrittlement was reduced. They had also found that embrittlement at sub-normal temperatures was also reduced by using fine grain steel. Manganese was ineffective in producing fine grain, silicon had some effect, but this was not nearly so great as was the effect of aluminium. Mr. Knight had asked for information with regard to fine grain in steel castings, but he was sorry he could not give him a definite answer. The subject was being tackled from the ingot onwards, and materials were being examined right from the ingot state. So far as the ingot represented castings, some information would then be available. He would expect the results to be on similar lines, assuming the castings were treated to bring out the different properties such as were brought out in wrought steel, but he was sorry he could not yet give any facts.

In reply to Mr. J. T. Wright's remarks on the question, as to whether steels produced normally had a grain size of three, the answer was "Yes." He agreed that there was a slight anomaly in the carbon case-hardened steels, where, in one case, the fine grain tests were slightly lower than the coarse grain steels. The differences between the coarse and fine grained steels under various conditions of quenching were not particularly great, but all of them of the order of only 100-ft. lb. It was in the low alloy steels that the main differences were brought out.

Mr. Bamford had also mentioned the question of oxygen in steel and its determination, but the whole difficulty lay in determinating the oxygen content. A report would shortly be issued which should indicate the state of the art in this direction at the present moment, and he was glad to say that reasonable agreement was being obtained by three sets of workers. A lot of figures had been published to show oxygen contents of steel, but one required to exercise a good deal of discretion in accepting them. There was one method which had promise of practical usefulness—namely, fractional vacuum fusion. It was believed that ferrous oxide and manganous oxide could be completely reduced at 1,150° C., silica at 1,350° C., and alumina at 1,650° C. The newer forms of furnaces would make the vacuum fusion method much more readily available, and if they could get the FeO-MnO fraction accurately and quickly, the information would definitely be of great value.

Mr. Kipling stated that after a long experience he had always found that steels of controlled grain size, either machined well, but at the same time warped, or did not machine so well and did not warp. Dr. Swinden said this was useful testimony that the information one had concerning machining and warping was reasonably accurate. On the point of better hardness being desired, he suggested the possibility of a slight modification in composition which would achieve this whilst still retaining the advantages of fine grain steel.

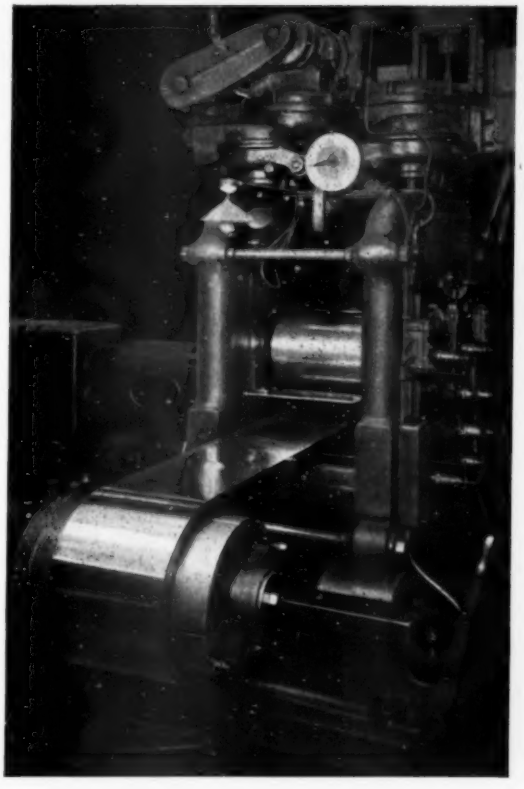
Most of the higher alloy steels, as produced to-day, were comparatively fine grained. Such work as had been done indicated that the difference in impact test with equal tensile was not so marked with the high alloy steels as with the straight carbon and low alloy steels. It was recognised that for some purposes, what might be termed the medium alloy steels, might preferably be made with medium grain size.

There was difficulty in obtaining laboratory evidence with regard to distortion, but from his experience, Dr. Swinden said he would expect greater freedom from distortion, even in sections which hardened right through, if the steel was fine grained. Many high carbon steels having fine grain, and, therefore, be regarded as shallow hardening, were used with advantage in sections which must harden throughout, and in such cases there was greater freedom from distortion.

COLD-ROLLING DEEP-DRAWING STEELS—PART III.

By J. L. TURNER

The properties of deep-drawing steels are governed by details in manufacture, the conditions under which they are hot-rolled, subsequent cold-rolling and heat-treatment, and the reaction of these factors upon deformation. Some of these factors have been discussed in preceding issues, and in this, the final article, the author discusses the mechanism of deformation, heat-treatment, refinement of structure and the effect of straining and heat-treatment on the steel.



Cold-rolling strip in a cluster mill at the works of Arthur Lee & Sons, Ltd.

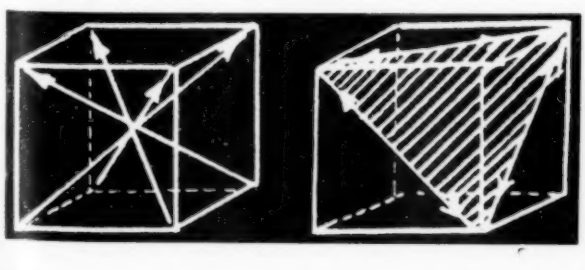
The Mechanism of Deformation

Deformation in a crystal occurs by shear—*i.e.*, by the sliding of one layer over another. The planes upon which sliding occurs and the direction in which movement takes place are related to the inner structure of the crystal—*i.e.*, dependent on the arrangement of the atoms in the crystal. In the case of ferrite—where the atoms are arranged on the body-centred lattice, each crystal may be pictured as built from a series of cubes arranged in an orderly manner. The direction of movement in ferrite is always along one or more of the four diagonals joining opposite corners of the cube. The inner atomic structure of a ferrite crystal is represented by a cube. The four possible directions of slip are indicated by arrows shown in Fig. 8.

The plane of slipping varies with the direction of stress, but must always be a plane containing one of the diagonals. It is probable that in general the plane is really made up of two separate crystallographic planes, the average direction of which coincides with the planes of maximum shear in the crystal. In ferrite, therefore, the slipping may be compared with the sliding of a series of corrugated sheets over one another. Austenite crystallises in the face-centred lattice, the slip planes coincide with the crystallographic octahedral planes and the direction of slipping is parallel with one of the three directions of closest packing of the atoms.

Fig. 8.—Showing slip directions of a ferrite crystal under stress.

Fig. 9.—Showing slip direction of an austenite crystal under stress.



The atomic arrangement is represented by a cube, as in Fig. 9, with one of the four octahedral planes shown cross hatched and the three directions of slip indicated by arrows. The presence of crystal boundaries has a strengthening effect on metals. For example, finely crystalline metal, where the area of boundary per unit volume is very large, has better properties than coarsely crystalline metal, where the area boundary is relatively small, consequently it is often said that the metal at the boundaries is stronger than in the body of the crystals. The slipping movement set up during deformation causes several important changes. First, a change in the shape of the crystals; second, a change in the orientation of each individual crystal; and, third, a change in the physical properties of the aggregate.

Figs. 10, 11 and 12, show the effect of progressive working in deep-drawing steel. Fig. 10 shows the elongation of the crystals resulting from a 40% reduction. The boundaries are still clearly visible, while within the grains dark markings show those planes where the slipping has been most severe. Fig. 11 shows the same material with 80% reduction, and the boundaries can only be distinguished with difficulty. Dark markings within the grains are now very pronounced. In Fig. 12 the steel has been reduced 95% and the structure shows thread-like crystals, some dark and some lighter, with the boundaries indistinguishable at this magnification.

When a crystal changes its shape by slipping, it also changes its orientation as shown in Fig. 13. Consider, for instance, a crystal (1) A B C D having the orientation represented by the arrow and slip planes aa, bb, etc., subjected to a compressive force, say by means of a testing machine, the dies of which cannot twist. Slipping occurs so that the shape of the crystal becomes as represented by No. 2, but the crystal faces A B and C D are in contact with the compression plates, and must, therefore, remain horizontal, hence the crystal turns into the position as shown at No. 3, thereby changing its orientation.

It may be shown that when an aggregate of iron crystals is subjected to continuous deformation in the same direction, a similarity of orientation is developed, each crystal

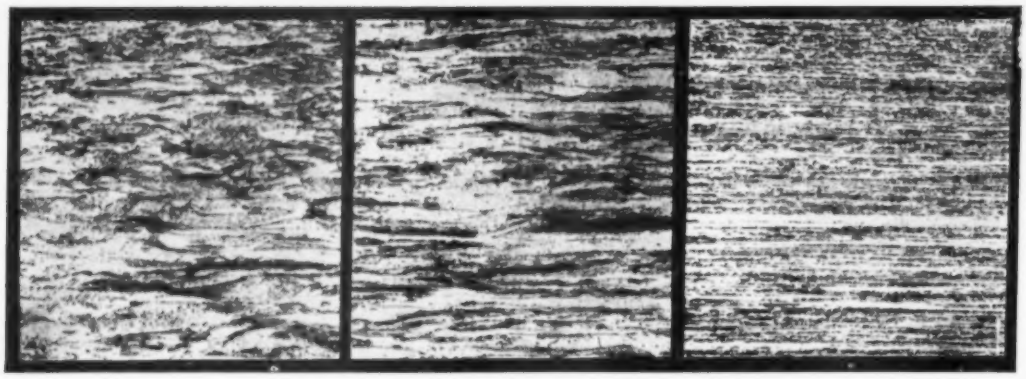


Fig. 10.—Elongation of crystals resulting from 40% reduction. *Fig. 11.—Same material after an 80% reduction.* *Fig. 12.—In this case the steel has been reduced 95%.*

The effect of progressive working deep-drawing steel.

turning so that its orientation bears the same relation to the axis of a stress. The movement of the slip planes throws minute portions over into new orientations. The illustration Fig. 14 shows a portion of a large ferrite crystal which has been subjected to intense cold-rolling. Here the changes in orientation, caused by the rolling, are on a sufficiently large scale to be readily visible. The intersecting dark bands are due to portions of the crystals having changed over to new orientations. The crystal fragments produced on the slip planes, having a different orientation from the parent crystals, have, as a consequence, planes of slip in a different direction and hence tend to prevent further slipping.

Heat-treating

Before the steel can be used for pressing or otherwise manipulating, it is necessary to secure the atomic reconstruction of the distorted grains. The temperature at which recrystallisation occurs and the number of centres from which crystals grow, varies with the degree of distortion. The process of recrystallisation is complete when the whole of the old grains have been absorbed by the new grains. The crystal size at the completion of the recrystallisation period is dependent on the number of centres from which growth is indicated and hence on the degree of distortion.

Recrystallisation is never complete at the temperature at which it commences owing to lack of uniformity on the distortion. Also, the time factor must be taken into account, because for long periods of annealing, slightly lower temperatures will give the same results. There is a certain critical degree of rolling below which recrystallisation will not occur whatever the annealing temperature, unless, of course, the steel passes from the alpha to the gamma.

Instead of recrystallisation and a decrease in crystal size, some of the distorted grains undergo lattice repair (fundamentally this is recrystallisation without change in the number of grains) and proceed to grow at the expense of their neighbours. The most critical straining is brought about by increasing the tensile strength from 20–24 tons per sq. in., and causing an abnormal increase in grain size of the ferrite crystals.

Whether recrystallisation due to working has occurred or not, on reaching 700° C. a portion of the iron will change over to gamma. The portion which makes the change is that intimately associated with the carbon. As the temperature rises, more and more of the alpha iron will change to austenite, so that by the time a temperature of about 875° is reached, the whole of the ferrite has disappeared and the structure consists solely of austenite grains. The size of the austenite grains will be related to some extent to the number of pearlite patches previously present. On cooling down the austenite will begin to deposit ferrite at approximately 875° C., the ferrite grains beginning to form round the boundaries of the austenite grains, the number growing varying with the rate of cooling. The essential factor determining the number of points of growth is the size of austenite grains. At 700° C. the remaining austenite breaks down to ferrite with the simultaneous deposition of carbide.

Uniform Distribution of the Elements Present

All ingots are subject to segregation, and, broadly speaking, that portion which solidifies first will be purer than the average, while there will be an enrichment of impurities, as well as carbon, in the central portion of the ingot. In addition to this type of segregation, there is also segregation or coreing within the crystals. It is very desirable that deep-drawing steels be of uniform composition, particularly as regards carbon. If all other elements were uniformly distributed in the steel, it would be a simple matter to get the carbon distributed also, the carbon diffusing at a rapid rate at high temperatures, but when the phosphorus is segregated it is a matter of great difficulty to get a homogeneous structure.

Phosphorus raises the austenite to ferrite transition temperature, so that ferrite begins to deposit first, on cooling, in the high-phosphorus area, thus leading to the concentration of the carbon in the low-phosphorus areas. Such a segregated structure leads to poor physical properties in the finished strip. Unless the phosphorus distribution is uniform, the carbon can only be made uniform by rapid cooling. Phosphorus diffuses very slowly in steel even at high temperatures, and it is desirable, therefore, that segregation in the ingot should be as little as possible. As the carbon is increased the segregation of phosphorus during solidification becomes more marked, thus, strip-rolled from a steel of 0·05% carbon is less likely to suffer from an uneven distribution than a steel of 0·10% carbon. Slip during rolling may bring segregated areas into contact with the impoverished area and, if cooling is not too slow, a certain refinement of elements may be obtained.

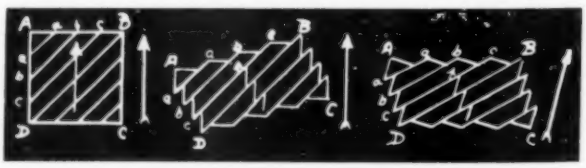


Fig. 13.—Diagram showing how slip of the crystal changes its orientation.

Effect of Critical Straining and Heat treating

When dead-mild steel is cold-rolled to an extent that is brought about by a reduction between 7% and 20%, subsequent annealing will cause abnormal growth of the ferrite crystals. The higher the annealing temperature, provided the straining corresponds with the critical degree, the larger will be the crystals, but they will take longer to grow. The higher the temperature the more sensitive is the material to small variations of strain. Strains, less than the critical amount, followed by annealing will not cause crystal growth. Very severe rolling causes re-

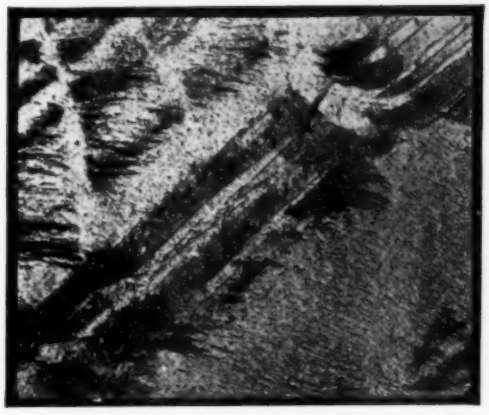


Fig. 14.—Change in orientation of a ferrite crystal after being subjected to intense cold rolling.

crystallisation at the lowest temperature possible, and produces the finest crystal size.

The diagram Fig. 15 illustrates the chief characteristic concerning growth and shows the critical strain required to produce largest crystals below 730° C. Carbon has a marked effect in preventing growth between A_1 and A_3. Largest crystals of all may be produced by very low straining and temperatures approaching A_3, using carbon-free material. The presence of pearlite gives rise to inequality of strains, and in this way, whilst some crystals are correctly strained, others are so highly strained as to cause recrystallisation. The character of carbide will, of course, vary according to treatment.

At 675° C. and over, specimens strained 10% will show largest ferrite growth; 7% reduction will not show much growth in central parts, but there will be medium large crystals on outer edge. If the steel is a dead-soft quality, growth at this reduction may be abnormal in the chill zone where it is practically carbonless. Growth will take place throughout if strained, 7, 8 and 9% in each case, being more marked towards the outer edge. The greater the strain above 10% the smaller will be the crystals. Temperatures above 730° C. give results different from

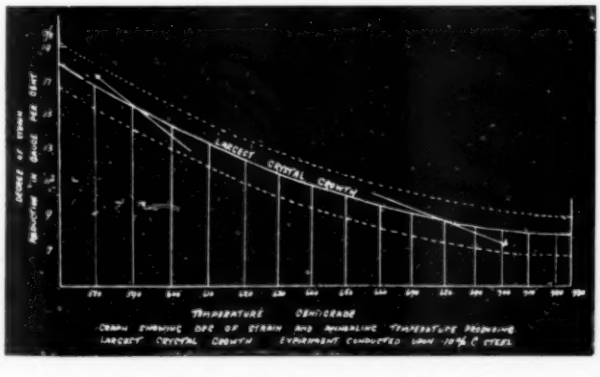


Fig. 15.—Diagram showing the chief growth characteristics.

those below since the amount of strain required to give the largest crystals has to be increased as temperature is raised above 730° C., whereas the reverse is the case with temperatures below 730° C. The micrographs shown in Fig. 16 illustrate successive stages of growth.

Manufacturers of deep-drawing steels are aware of the importance of grain size in their product and are able to control this within limits that are closer than the differences observed in the performance of the material. From what has been said it will be appreciated that the properties of strip steel may be adversely affected by any and all of the processes involved in cold-rolling.

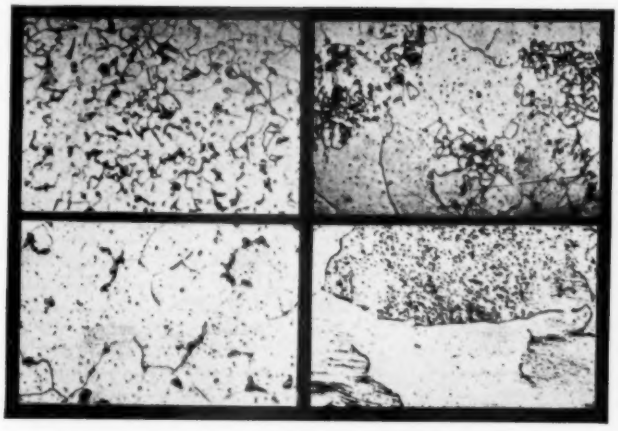


Fig. 16.—Micrographs showing successive stages of growth.

Close control of all cycles is therefore necessary to produce the desired intermediate type of structure which will give maximum tenacity and ductility. Deep-drawing steels in the annealed or normalised condition produce stretcher strains when drawn to shape which are an indication of the passing of the yield point in localised portions of the steel. Further treatment to prevent this condition arising must be undertaken, and this final treatment is the vital factor in arriving at the most suitable condition for the successful manipulation of the steel.

This treatment, however, leads to other complications, notably, age hardening, and this aspect of deep-drawing steel is probably the most aggravating both from the metallurgists and the press users' point of view. The yield ratio, maximum stress, and hardness all increase, while both the elongation, Erichson or Olsen values have decreased by as much as 10% of the original values. It is therefore, highly desirable that the manufacturer be aware of the final treatment of his product.

The various designations of hardness and finish are not uniform throughout the industry, and in any case are difficult qualities to measure. Finish is largely a matter of expert judgment as there is no method of measuring this quality. Neither should a great many of the tests applied to the physical properties be used within too rigid limits, on account of the slight variables in analysis and other factors, and also because these tests are likely to prove inaccurate on thin material.

The author desires to express his thanks to his employers, Messrs. Arthur Lee and Sons, Ltd., for permission to publish this article and, in particular, to Mr. G. Wilton Lee for his assistance.

Copper in Chemical Plant

Copper has a high degree of resistance to corrosion under a wide range of conditions, and for this reason it is used in preference to many materials for the construction of chemical plant. In addition to corrosion resistance, copper possesses a variety of properties which further increases its suitability for such purposes. It has good strength, which is maintained at moderately high temperatures; its strength can be substantially increased by cold-working; it is very ductile in the annealed state, and can readily be worked into complex shapes; it lends itself to a variety of joining methods such as welding, brazing, soldering; and it has a very high heat conductivity.

All who are interested in the construction of chemical plant will find this book of considerable value; it deals with the properties of copper, copper alloys, metallic coatings on copper, copper work, heat transfer, and copper equipment in typical industries in a very informative manner, and it will be found excellent for reference purposes. It is published by the Copper Development Association, Thames House, Millbank, London, S.W. 1, a copy of which may be obtained on application.

Grey Iron and Its Applications to Engineering

PRODUCED at low cost with a wide range of physical properties, cast iron is widely used in engineering and allied industries, but its attainable properties are not generally appreciated and are frequently subordinated to low cost with a sacrifice of utility. This is due in a large measure, said Mr. A. Campion, discussing the subject before a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, to an incomplete understanding on the part of the engineer, of the properties possessed by modern cast iron, types of material, and sometimes to a lack of proper methods of testing.

The future progress of engineering design and construction will be greatly influenced by the degree of success achieved by the metallurgist in the production of material to conform to more stringent specifications as to mechanical properties, and by the founder in improving his technique so as to enable him to cast such material. In the past few years casting practice has kept pace with the requirements of engineers, and there is every hope that it will not only keep pace but anticipate the requirements of progressive engineers in the future.

Until the beginning of this century foundry practice remained an art rather than a science, and castings were not greatly improved to that time. Ten years ago a request for cast iron with a tensile strength of from 16–18 tons per sq. in. was considered something exceptional. To-day, however, cast irons with tensile strengths of from 25–30 tons per sq. in. are regular products of the cupola. In addition, the use of alloy additions and developments that have been made in heat-treatment have increased the possibilities of securing increased properties and a uniform quality of cast iron.

The chief features of the processes that have been introduced for the production of high-test cast iron are :—

The use of steel scrap or lowering of the silicon content in the charge.

Lowering the total carbon and phosphorus contents.

Superheating in melting.

Control of graphitisation by chemical composition or rate of cooling during solidification.

So far as superheating in melting is concerned, the greater the amount of carbon contained in the iron the greater is the difficulty in controlling the form and distribution of the graphite and the grain of the matrix, both of which are of equal importance in the determination of the physical properties of a casting. On the other hand, the lower the total carbon content the more difficult it is to obtain a uniform softness and homogeneity of the structure of the casting. In addition to those mentioned above, another well-known method of conferring enhanced properties upon cast iron is by means of alloy addition, usually nickel, chromium, molybdenum and occasionally titanium, vanadium, tungsten and silicon.

Almost all the methods that have been developed to improve the properties of cast iron have consciously or unconsciously attempted to control graphitisation, whether resort has been made to the use of steel in the mixture, whether carbon and silicon have been reduced by special mixtures in melting conditions, whether superheating of the molten metal has been effected, whether hard iron has been graphitised by pouring into heated moulds, or whether alloys or heat-treatment have been involved. The results of all these different methods of attempting the same object are seen in the superior cast irons available to-day, although progress has not been proportional to the scientific attention and research that have been applied. This can be partly explained by the necessity of retaining the identity of what is usually understood as "common cast iron" together with an economic advantage over steel.

Mr. Campion directed particular attention to the work of Meehan, who in 1926 experimented in the manufacture of grey iron of superior strength and physical properties. The development of this type of iron has been carried on by Smalley and others with successful results. The particular type of high-test iron made by Meehan's process and known as "Mechanite" can be controlled to meet definite service requirements, and possesses superior physical qualities to cast iron or semi-steel. The metal of each single casting may be changed to meet a given set of conditions in the way of mass influence as it affects strength, hardness and machinability, so that uniform strength properties in castings of varying section are assured. The author describes many tests, and suggests particular applications of the various grades of this type of cast iron.

The Change of Magnetic Properties of Ferric Hydroxides by Heating in Different Gas Atmospheres

BROWN iron ore, the natural ferric hydroxide, is paramagnetic only to a small extent, so that direct magnetic dressing is not economical. It is, however, possible to change it into a ferromagnetic form by heat-treatment—the "magnetic roasting." This can be done by two different methods : by reduction alone, or by reduction first and reoxidation subsequently. In the first case the iron oxide is converted into magnetic ferrous-ferric ocide ; in the second case ferromagnetic oxide (γ-iron oxide) is formed by reoxidation. Both methods, therefore, involve reduction as an important part of the roasting process. The α-hydroxide is the only one in natural brown iron ore ; it is converted to paramagnetic iron oxide by heating and expelling the water of hydration.

Investigations of artificial hydroxides and three different examples of German brown-iron ores are made to find out the special conditions for converting iron hydroxides, especially natural ones, into the magnetic state. Experiments by heating in nitrogen and carbon dioxide at temperatures between 200° C. and 900° C. have resulted in a variable behaviour when changing the magnetic character, which depends on the decomposition of iron carbonate or alkaline earth carbonate. Experiments in a reducing atmosphere of carbon monoxide have given a maximum magnetisability at 500° C. for all samples, although the quantities of protoxide oxide are small. Much ferrous oxide could be found at the end of the experiments. The samples reduced at 600° C. were much less magnetic. That seems to indicate that a reduction does not result in paramagnetic ferrous oxides if the temperature of reduction is below 570° C. The hydroxides can be converted easily into ferromagnetic Fe-oxide, but that is not possible with ferric oxides formed at high temperature.

The conditions of temperature for reaching the maximum magnetisability are different for artificial and natural hydroxides ; for the latter, temperatures of reduction of 550° C. to 600° C. and temperatures of oxidation of 500° C. to 550° C. are the most favourable.

The speed of conversion of brown-iron ore for reduction and oxidation is already very high at a temperature of 400° C. That is probably brought about by loosening the crystal structure in expelling the water of hydration, and by the strong tendency to forming γ-oxides. Therefore the conclusion can be drawn that for the natural ferric hydroxides there are very favourable possibilities of calcination as a means of facilitating the magnetic separation.

Communication by Ludwig Kræber and Walter Luyken from the Kaiser-Wilhelm Institute of Research on Iron and Steel. No. 307.

The U.S.S.R. produces daily an average of 66,000,000 kw.-hours of electric energy ; 350,000 tons of coal ; 89,000 tons of oil ; 55,500 tons of coke ; 83,000 tons of iron ore ; 39,500 tons of pig iron ; 48,800 tons of steel ; 37,500 tons of rolled metal.

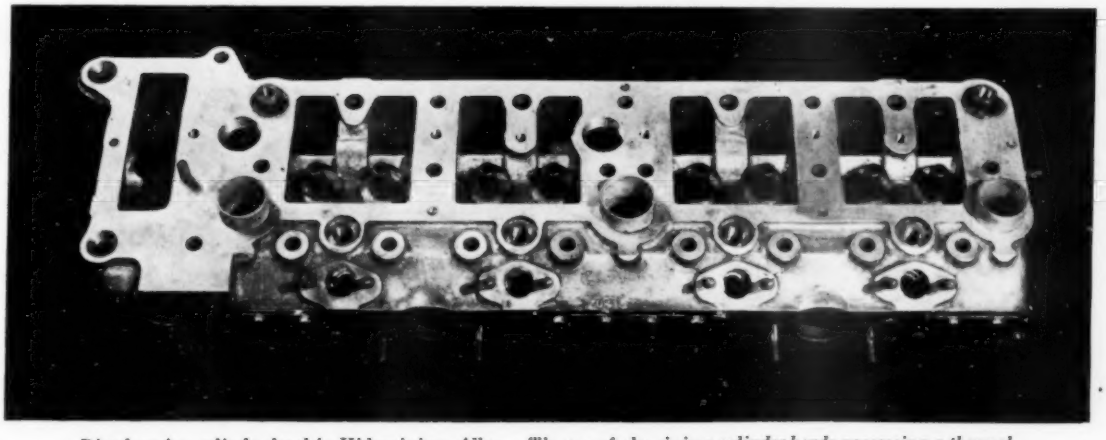
The British Industries Fair

Some Outstanding Features

The British Industries Fair, which opens in London and Birmingham on February 15 and extends to February 26, is the largest and probably the most interesting yet held. It will be memorable because of the Coronation, and also because of the trade revival being experienced. In this review attention is directed more particularly to important features at the Birmingham Section where notable developments associated with metallurgical progress are exhibited.

SINCE its inception in 1915 the growth of the British Industries Fair has been remarkable. Originally comprising only five groups, composed of exhibits which occupied an area of 90,000 sq. ft., last year the space occupied totalled 823,000 sq. ft., and 75 trades and industries were represented. Although not yet fully representative, as several important industries continue to hold separate exhibitions, this year's Fair shows every indication of being the largest yet held. Recognised to be by far the largest display of entirely national manufactures held in any part of the world, this Fair is organised by the Department of Overseas Trade with the object of bringing together potential buyers and manufacturers to promote sales.

Much courage has been shown in the metal-producing industries during a critical period of depression, and considerable reorganisation has been effected to modernise works so that their products can compete favourably in the world's markets. Recent years have seen substantial modifications to existing plants, the installation of new plants, and, in some instances, complete new works have been constructed and equipped. Although the expenditure involved in the various reorganisation schemes has been of a high order, the importance of research work has not been overlooked; in fact, the value of research work is increasingly appreciated. The developments in almost every branch of engineering in recent years can be traced largely to the results of metallurgical research. To show



Diesel engine cylinder head in Hiduminium Alloy. The use of aluminium cylinder heads possessing a thermal conductivity of about three times that of cast iron, and with higher compression ratios, is now well established.

The British Industries Fair differs from the majority of exhibitions of this type in that it is concerned entirely with British potentialities in the industrial field. Only goods manufactured or produced within the British Empire are displayed, but these cover such a wide and comprehensive range that a purely national event of this character is fully justified. The very fact that it has grown so rapidly, during a period when this country and the rest of the world suffered a severe industrial depression, shows that valuable business results.

In addition to developing business, this annual Exhibition demonstrates the progress of science and art in the service of mankind, and the extent to which the British are contributing. Although a year is a comparatively short time during which progress can be shown, even in comparison with last year's Exhibition, the casual visitor will note a progressive tendency, while the more-discriminating visitor will appreciate the developments in plant and equipment, or in the techinque employed in manufacture to achieve the results indicated by many products exhibited. On the metallurgical side both ferrous and non-ferrous metal industries have made commendable improvements that have resulted in higher-quality products, the effect of which is appreciated in every branch of engineering.

that new processes are frequently dependent upon the provision of materials of construction which possess the necessary characteristics, it is only necessary to mention how the petroleum, chemical, electrical industries, and also high-temperature steam-raising units have progressed as a result of the development of alloy steels and non-ferrous alloys.

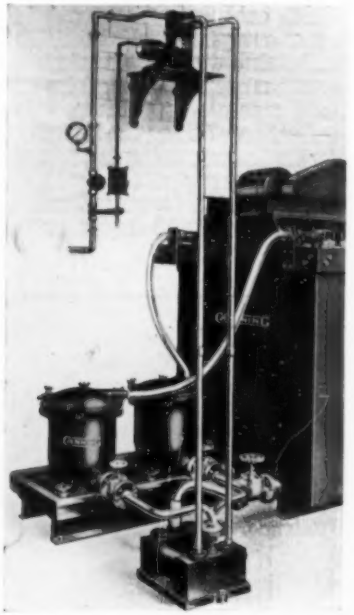
The display of what are termed the heavy industries, at Castle Bromwich, is so comprehensive that it would be impossible to deal with them adequately here. In this review, therefore, it is proposed to refer to some of the outstanding exhibits that have a distinct bearing upon ferrous and non-ferrous metal production, in finished and semi-finished forms, together with the developments and products of those industries closely associated as users of these materials. Various forms of plant and equipment in which developments have been incorporated will also be discussed, and an effort made to direct the visitor, with limited time at his disposal, to some of those exhibits which have outstanding qualities. A number of important and interesting exhibits have been unavoidably omitted, because reliable information regarding them is not available at the time of going to press.

METALLURGICAL DEVELOPMENTS

Iron and Steel

Metallurgical developments come slowly to fruition, and records of discovery frequently lack the spectacular suddenness and surprise element. It must be realised that all developments must be proved before they can hope to be accepted and become definitely associated with the fields of service for which they are designed. Frequently acceptance involves such a change in procedure that economical considerations, and the want of manipulative knowledge, retards the application of a development that would have distinct advantages; but mainly owing to intelligent foresight exhibited during the industrial depression, when most useful research work was carried out, a number of interesting developments have been effected, which are reflected in the exhibits.

Base and lid of wiring system joint-box, with set of tools of Edgar Allen K-9 steel, made by British Insulated Cables, Ltd.



Filtering apparatus for electro-plating solutions, as arranged for existing air supply, by W. Canning & Co.

Steady progress is shown in both the ferrous and non-ferrous metal industries. Considerable work, for instance, has been carried out on steels possessing strength and stability at high temperatures. At moderately high temperatures of 350° to 550° C. it is necessary to have a low rate of creep under as high a stress as possible, with no reduction of the properties after long exposure to these temperatures. Among some of the important results of investigations is the beneficial influence of molybdenum, and the effect of the addition of chromium. It has been found, for instance, that up to 1% of chromium gave a big improvement in the creep properties. Chromium has also been shown to be beneficial in steels, for use at very high temperatures, up to 1,000° C., in reducing attack by oxidising and sulphur-bearing gases; but the fabrication of chromium steels of high-chromium content presents some difficulties, and the introduction of nickel has proved helpful in this direction. Not only does the addition of nickel to a high-chromium steel improve the workability of the steel, but it improves the strength at high temperatures.

Corrosion-resisting steels of a great variety of compositions are now used for a wide range of applications, including domestic and office fittings, furniture and utensils, apparatus and plant for the manufacture of chemicals, also for industries in which chemical processes are used; the manufacture and transport of foods, mechanical and civil engineering, and in the construction of scientific instruments and apparatus. The original steels in this class contained from 12 to 14% of chromium, with a carbon content of 0·30 to 0·40%. The low carbon content rendered it impossible to fabricate the material into many forms. Since their inception, however, there has been much progress, and corrosion-resisting steels are available which fulfil practically every requirement in fabrication. So many grades are now manufactured that it is profitable for the user to state the purpose for which the steel is required, in order that the manufacturer can determine the most suitable grade.

Amongst other high-alloy steels in which advances have been made, mention may be made of magnet steels, types of which have been developed which exceed in their performance that of cobalt steel, which seems to indicate that the alloy steel field is as fertile as ever and worthy of careful search. In the manufacture of tool steels also new types of steel have been introduced in which rather large percentages of cobalt are incorporated. In addition to better performance in rate of machining, these steels are able to accomplish tasks beyond the capability of the tungsten - chromium and tungsten - chromium - vanadium types. A new tungsten-carbide type of tipped cutting tool has recently been introduced which is made by moulding the powdered alloy the required shape, and, after sintering, it is brazed to a steel shank.

The number and variety of low-alloy steels now available for high-tensile and structural purposes have greatly increased in recent years, and their usefulness has made considerable progress during this last year. For many applications the choice of available steels is almost embarrassing. To the older chromium, nickel, and nickel-chromium steels there are now added such combinations as chromium-vanadium, chromium-molybdenum, nickel-chromium-molybdenum, nickel-molybdenum, and manganese-molybdenum, with varying percentages of these elements. One of the most recent and noteworthy arrivals is the manganese-molybdenum steel, which is finding ready acceptance when a steel is required, having superior properties than a carbon steel of similar carbon content, at relatively low cost.

Considerable attention has been given to the subject of

controlled grain size in steel. The fact that it is possible to produce from the same melt either coarse-grained or fine-grained steel, which, given the same heat-treatment, exhibit widely different mechanical and physical properties, is focussing attention upon grain size and on selection, by the user, of the most suitable size for his specific purpose. It is being gradually recognised that there is no similarity in steels and their behaviour on heat-treatment, cold- and hot-working, even if their chemical compositions be exactly the same, unless they belong to the same class with regard to inherent grain size. Investigations are in progress with a view to further information on the subject, so that it may be possible to use a steel of particular grain size for a specific purpose with full knowledge rather than speculation. Developments in this direction will have a profound influence on metallurgical progress.

Non-Ferrous Metals

On the non-ferrous side it is probably true to say that progress in the technical development and application of aluminium and its alloys are proceeding much more rapidly than with any other metal or alloy. Considerable research has been carried out, and much is still in progress, and results are being put into operation with the least possible delay. Progress is based largely upon the results of research work, rather than on tradition, and this probably accounts for the rapid development of aluminium. Improvements in alloy compositions, fabricating methods and methods of design and construction have been studied, and recent advances in the application of this metal is largely due to a better knowledge of the fundamentals in these three fields.

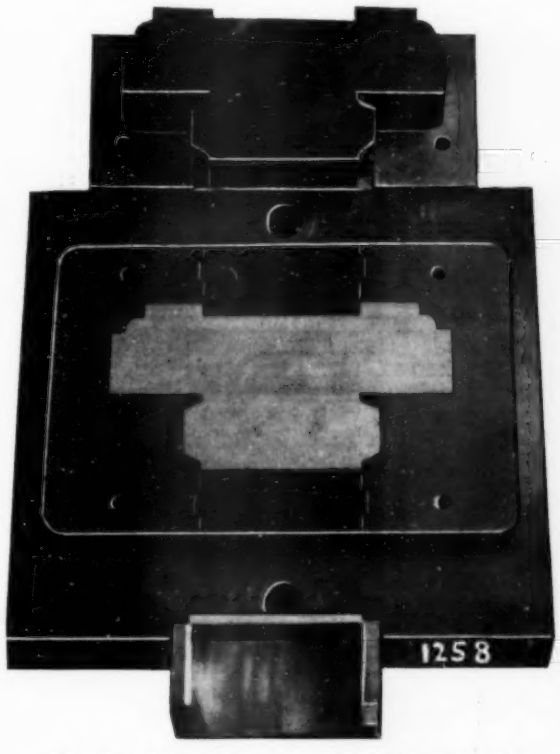
With the development of the strong alloys now commercially available, there was some delay in obtaining full advantage from them because available equipment and technique was inadequate. The character and size of parts for which these alloys were suitable were limited by these manufacturing difficulties. Continued investigation and the accumulation of manufacturing experience, including improved equipment, have now reduced these difficulties and made the use of these stronger alloys commercially possible for a wide range of purposes. These improved alloys were immediately useful in aircraft manufacture, and have now become standardised for that class of work ; but in all the transport industries the use of aluminium and its alloys is making rapid headway.

The discovery of magnesium, about one-third lighter than aluminium, undoubtedly stimulated research in aluminium alloys ; but the growing competition of special alloy steels has also had a powerful influence on research, with the result that heat-treated alloys have been developed giving, in wrought form, about 30 tons tensile, 23 tons proof stress, and 10% elongation. These depend upon the hardening effect of copper with magnesium and silicon, and represent refinements in materials already established rather than innovations ; but it shows that those interested in the aluminium industry are alive to the need for constant research.

One of the outstanding advances with aluminium and its alloys is that concerned with fabrication. Wrought structures of large size are now made as regular routine operations. The technique of forging has developed, and hot-pressing, which is similar to forging in many respects, has proved particularly advantageous for highly stressed parts. There has been increased appreciation also of the value of composite sheet, in which a strong alloy core is covered and protected by means of a thin layer of high-purity aluminium integrally bonded to each surface.

Another development is concerned with the surface protection of aluminium articles. For many years the anodic oxidation of aluminium in phosphate, or borate electrolytes, was used to a limited extent. Subsequently the use of chromic-acid electrolyte was found to produce a thicker and stronger coating, which was especially well adapted to serve as a basis for paint in the protection of aircraft structures. Now, anodic oxidation in sulphuric or oxalic solutions has enabled the application of heavier coatings, and a variety of treatments make it possible to control the absorption power of these coatings for dyes, pigments, corrosion-inhibitive chemicals, etc. The superior hardness and abrasive resistance of these modern oxide coatings is an indication of the progress achieved. A further recent discovery of considerable interest is a process that brightens as well as protects the metal. This is a simple two-stage electrolytic treatment—the first in sodium-carbonate and sodium-phosphate bath, and the second by anodic oxidation—which is successfully applied for reflectors.

Magnesium, which is finding increasing usefulness, is too weak to be used alone, and there are only a few metals with which it can be combined. Of these only aluminium and cadmium can be alloyed in more than small quantities. Investigations have shown that magnesium alloys with an appreciable percentage of aluminium are relatively strong and easy to cast, and these castings are proving valuable

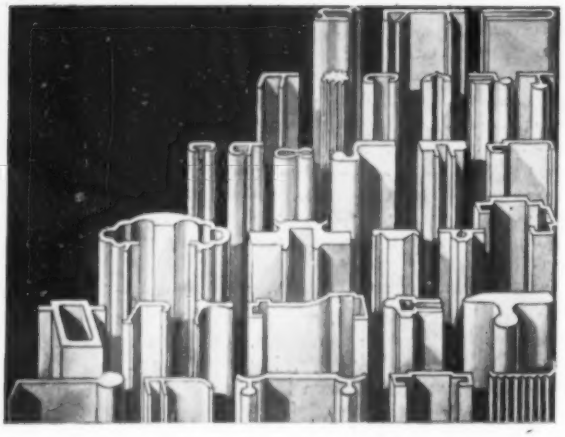


Coin box of prepayment meter, with blanking tools of Edgar Allen K-9 steel, made by British Insulated Cables, Ltd.

in aircraft work. Technique has been developed to enable the extrusion and pressing of these alloys to be successfully accomplished in practice, while drop stamping and forging are also carried out successfully. Investigations have shown that aluminium, silver, manganese, calcium, nickel and cerium strengthen magnesium. The advantages offered by the application of magnesium has been freely recognised by the aircraft industry, and considerable progress has been made in its use.

The major metallurgical developments with copper are concerned with the application of this metal in the iron and steel industry. The advantages of copper-bearing steels in applications subject to corrosive conditions, as in roofing, gasometers, air-conditioning plant, etc., are now well established. When alloyed with copper and small percentages of certain other elements it is possible to obtain cheap alloy steels, which possess advantages due to improved corrosion resistance, and which also possess superior mechanical properties.

Copper has a high degree of resistance to corrosion under a wide range of conditions, and is therefore used extensively



Range of non-ferrous metal sections by McKechnie Bros. Ltd.

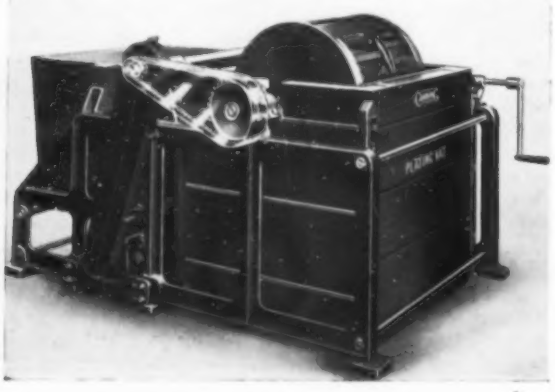
in plant construction, while in the form of tubes it is being increasingly used for water supplies, for pulp lines in the paper industry, air lines, oil supply lines, vapour lines, etc. Developments with copper alloys, as with other products, usually take place over a period of years, and anything of a startling character is seldom experienced. Brass tubes with relatively high-copper contents are usually prepared for corrosive waters. The cupro-nickel alloys are making progress in the condenser-tube field, and silicon-bronzes are being increasingly applied. Some of the newer alloys comprise aluminium-brass for condenser use, and especially a recent modification containing both tin and aluminium. An alloy of great promise is nickel-aluminium-bronze with rather high nickel and aluminium content.

Investigations with such metals as lead, tin, zinc and antimony are developing new uses for these metals; new or modified alloys, with improved properties to meet particular conditions. The addition of a very small percentage of tellurium to lead, for instance, has enabled this metal to meet much more drastic conditions. Elsewhere in this issue brief reference is made to one of the many fields in which another metal, nickel, is contributing to modern progress. Tungsten, molybdenum and a number of rarer metals also have many useful applications in engineering, all of which are represented in some form at the Birmingham Section of the British Industries Fair.

Iron and Steel Products

Corrosion-resisting steels have so many applications that the various exhibits of this type of steel will probably provide the most interest among ferrous products. Prominent of these are the "Silver Fox" new process stainless steels, displayed on Stand No. D 711. These steels, which are produced by Messrs. S. Fox and Co., Ltd., one of the companies of the United Steel Companies, Ltd., group, are made by the high-frequency electric steel-melting process,

"Quickplate" motor-driven plating barrel by W. Canning & Co.



which ensures that they are exceptionally ductile, easy to manipulate, and take a brilliant polish, which is easily maintained. It is claimed there is a grade of this brand of steel for every application. A wide variety of finished products made from the various grades are shown, including examples of one of the qualities which gives freedon from weld-decay.

A comprehensive range of Firth-Vickers stainless and "Staybrite" steels are displayed by Firth-Vickers Stainless Steels, Ltd., which illustrate the diverse and ever-increasing applications of non-corrodible and heat-resisting steels for industrial, domestic and architectural purposes. Special attention is directed to applications of "Staybrite" steel for engineering and allied industries, also for the chemical, brewery, dairy and textile industries. Another stainless steel on view is the Edgar Allen "Maxilury." Of their wide range of alloy steels, Messrs. S. Fox and Co., Ltd., on Stand D 612/713, show applications of two of those recently introduced—viz., "Diamet" inspected steels, claimed to be the most perfect steels made by present-day technique, and "Durchete" creep-resisting steel; the former type is used chiefly in the automobile, aircraft and the machine-tool trades, the latter has been designed to meet the demands of the power-station and boiler-house engineer for a creep-resisting steel.

Since last year considerable strides have been made in the technique of stainless steel tube production, and several firms exhibit a remarkable range of tubes in this corrosion-resistant material. Prominent of these is Accles and Pollock, Ltd., who, on Stand D 812, make an important feature of stainless steel tubes. This firm is in a position to supply tubes made from practically every commercial grade of stainless iron and steel. On Stand No. D 521 the Britannia Tube Co., Ltd., also exhibit stainless steel tubes.

On Stand No. D 408, Thos. Firth and John Brown, Ltd., give prominence to the high-quality steels this company produces for all purposes. The display consists of forgings, including a section boiler drum and die blocks, a full range of castings, dredger buckets and spares, rolled steel bars, Nitralloy steel tyres, axles and springs, whilst the products of their engineers' tool department will be well in evidence. These will consist of wood-working tools—circular saws, long saws, cross-cut saws, wide and narrow band saws, machine irons and knives, and a range of engineers' tools made from "Speedicut" high-speed steel, Firth Insto saws, the millenicut file, with its milling cutter teeth and capacity for removing material, milling cutters, drills and reamers.

Reference has previously been made to developments in tool steels and tungsten carbide-tipped cutting tools, and in this direction the visitor will find much of interest on Stand No. D 831 and 730, occupied by Messrs. Edgar Allen and Co., Ltd. Here is exhibited a range of this firm's "Stag Allenite" new patented tungsten carbide-tipped cutting tools. These are shown for the first time. They represent an extension of the Edgar Allen range of cutting tools to cover cast-iron and non-ferrous materials. We understand these tools have been tried and tested thoroughly in many large engineering works up and down the country, and have been found tougher than the ordinary tungsten carbide-tipped tools.

A range of Stag Major Superweld tools are also on view. These tools are ended by electrical means with a solid piece of super high-speed steel, and are supplied in a large number of shapes and sections. A number of other grades of tool steel for different classes of work are also exhibited. Of particular interest also is the display of a varied range of press tools, screwing tackle, etc., made from Edgar Allen K-9 and Double-six die steels.

A wide range of tools tipped with "Wimet" tool metal is shown by A. C. Wickman, Ltd., on Stand D 508. Five grades of "Wimet" are exhibited associated with various types of tools, including twist drills, spot-face cutters, lathe tools, glass and marble drills, "Wimet" tipped gauges, work slides for centreless grinders, inserted blade milling

cutters, etc. Interesting exhibits are "Spedia" lapping wheels, "Spedia" hand laps and grinding wheels. "Spedia" lapping wheels are used for the final lapping of "Wimet" brand cutting tools, gauges and other hard metals where an exceptionally fine finish is required. They are the only known free-cutting wheels which will give a fine finish to the cutting edge.

Alfred Herbert, Ltd., on Stand D 409 also show a range of small tools and machine-shop accessories, which include the well-known range of Herbert dieheads, comprising the Coventry self-opening type, Tangic dieheads of the stationary type, Tangel stationary diehead, and several other types. A range of Ardoloy tipped tools is also displayed.

Of particular interest is a number of exhibits on Stand No. D 501/400, occupied by the Calorizing Corporation of Great Britain, Ltd. A few typical manufactures in Calorized mild steel and "Calmet" nickel-chrome heat-resisting metals are shown, comprising heat-treatment containers for case-hardening, cyanide, salt and lead hardening and annealing, also pyrometer sheaths. A number of interesting photographs on the stand show other manufactures, including large annealing pots used in the wire-manufacturing industry, Calorised mild-steel nitrate, and soda baths for the heat-treatment of Duralumin parts, Calorised steel tubes and "Calmet" alloy tube supports for oil-cracking stills, and Calorised mild-steel spiral conveyers, retorts, etc.

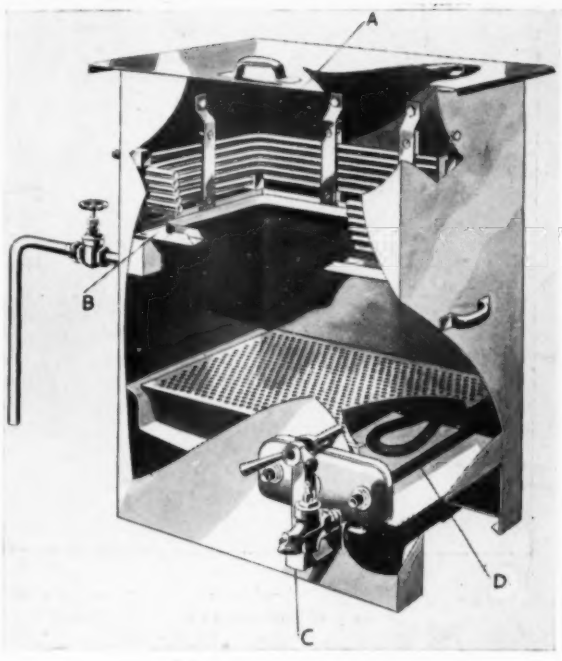
An interesting feature of the display arranged by the United Steel Companies, Ltd., is a complete model cinema, where films are shown of the manufacture of certain products. One of these films shows the mining of hæmatite ore at the company's Beckermet (Cumberland) mines. Another, the making of acid Bessemer steel rails, shows the working of a unique plant. The making of Appleby boiler plates, another film, shows all the major processes, from the mining of the ore to the showing of the finished plate. Those who desire to see the progress made in the production of high-quality steel should see the film, which depicts the manufacture of "Diamet" inspected alloy steels in the high-frequency electric steel and melting shop and rolling mills of Messrs. S. Fox and Co., Ltd.

A comprehensive range of products is shown by Stewart and Lloyd, Ltd. These extend from pig iron to large-size mild-steel pipes. On view are screwed and socketed tubes and fittings of gas, steam, galvanised and water quality; hydraulic tubes; "Perkins" hot-water tubes; heating, tuyere and other classes of coils; boiler tubes and oil and artesian well pipes. The sizes of the tubes exhibited range from ¼ in. to 54 in. bore, and in the larger samples there are samples of steel pipes with spigot and socket joints for water mains. A variety of joints are shown which are suitable for many purposes, each has individual merit—for instance, the sleeve and spherical types of welded joints for gas engineers' requirements; inserted joints for both coated and lined pipes, covering sizes up to 72 in. bore, for water engineers; long sleeve, taper joints, for gravitation sewers. In addition various other types of joints are shown.

A recent addition to Stewart and Lloyd's tubular products is the Elderslie tubular steel shore, which, although primarily designed for use in graving docks, can be adapted wherever supports of variable length are required for temporary purposes. Other products of the firm, which are on view, include steel and heat-resisting iron castings, steel sections, and samples of various ores, limestone, ganister and basic slags.

Pig Iron

Among interesting exhibits of pig iron, the display of the Workington Iron and Steel Co., should not be overlooked. This firm manufacture West Coast hæmatite iron, including "UCO" and other special qualities. Particular attention is given to the analyses of these specialities, and with the exhibits are actual products made from the various irons. The display includes samples of machine cast iron. This branch of the United Steel Companies, Ltd., also specialise in the manufacture of rails treated by the Sandberg regulated sorbitic and oven-treated process. Examples of these, together with steel sleepers, are on view.



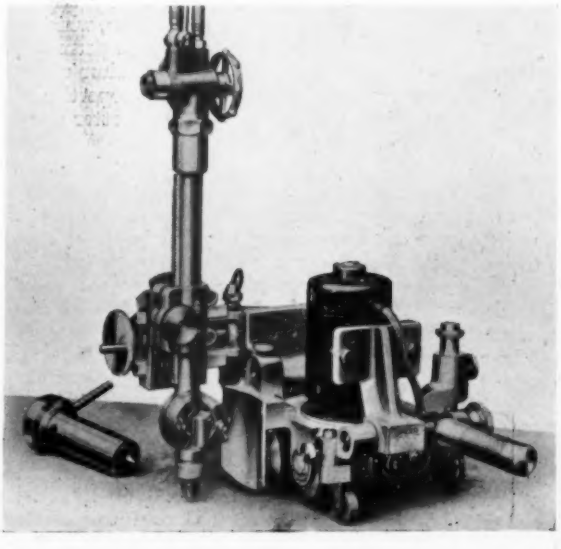
Popular "V" degreasing plant by I.C.I. Ltd.

Malleable Iron Castings

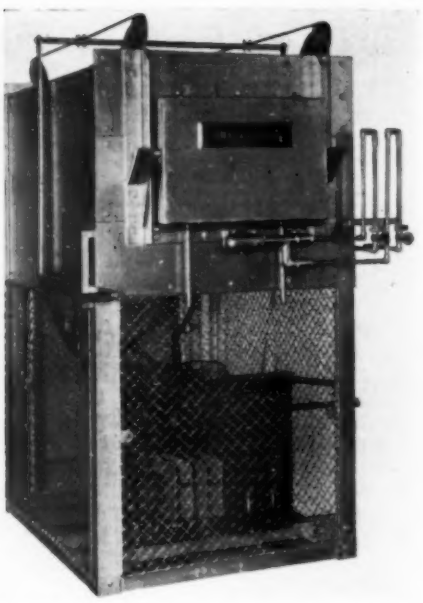
Progress during the year has been effected in the manufacture of malleable iron castings, and Thomas L. Hale (Tipton), Ltd., show products from their new foundry, which has been designed and equipped specially for the making of white-heart malleable castings. This firm has been manufacturing black-heart malleable iron castings for many years and supplies the British Admiralty, War Office and the principal home, colonial and foreign railways in addition to the engineering and allied industries; but, in addition to black-heart castings of high quality, it was desired to supply a material with higher tensile and somewhat lower elongation than black-heart, with the advantage which permits of subsequent heat-treatment processes, at high temperatures, not possible with black-heart. A very complete range of castings in both types is exhibited.

Other malleable iron castings shown include those produced by Leys Malleable Casting Co., Ltd., on Stand No. D 603/502. Leys specialise in the black-heart type,

"Circaline" portable automatic straight line and circle cutting machine by Hancock & Co.



Vertical forced air circulation furnace for heat-treating aluminium alloys and tempering stainless steel, by Wild-Barfield.



Wild-Barfield "Hairpin Minor" furnace for carburising, hardening and normalising small parts.

and claim that it is superior to other malleable iron made in this country. Owing to the strict control of composition and manufacture, a tensile strength of 24 tons per sq. in. is consistently maintained in contrast with B.S.S. of 20 tons per sq. in., and with an elongation of 18%, instead of 7½%, the cold-bend test being 180° instead of 90°. Typical castings exhibited include motor-car hubs, differential gear cases, etc., while a selection of Ewart's chains for power transmission, elevators and conveyers, are also shown.

Aluminium and Aluminium Alloy Products

One of the outstanding exhibits is that by The British Aluminium Co., Ltd., on Stand No. D 911/808, which shows recent and interesting developments with aluminium and its alloys. Here are exhibited high-strength aluminium-alloy forgings in Duralumin and Hiduminium alloys; pressure and gravity die-castings in light aluminium and zinc-aluminium alloys; "Aldural" sheet and M.G. 2 alloy rivets for aircraft; a very wide range of extruded aluminium sections; anodised and coloured aluminium structural work; and a "Bristol" Pegasus air-cooled radial aero-engine, lightened by the use of aluminium alloys to give a specific weight of 1·01 lb. per b.h.p. Particular attention is directed to the exhibits of free-cutting aluminium alloy, B.A. 35, which gives clean surfaces and screw threads without clogging, on fully automatic machines; to the "Brytal" reflector process, which gives aluminium 85% reflectivity with exceptional permanence; and to extruded sections coated with pure aluminium, for conditions where the superior mechanical properties of the alloys are required in conjunction with the better corrosion resistance of the pure metal.

The introduction of a free-cutting alloy has reduced difficulties encountered in the machine shop. The advantage of this metal over former alloys used for machining, lies entirely in its free-cutting properties, these enabling it to be machined at the same speeds and with much the same tools as leaded brass, while still giving short, curled, chips easily washed from the tool face. The advantage of this in fast and continuous working of automatic machinery will be readily appreciated by an inspection of the sample turnings and the demonstrations which have been arranged, through the courtesy of M.C.L. and Repetition, Ltd., to be given periodically on their Stand. This alloy may be satisfactorily anodised by the usual processes.

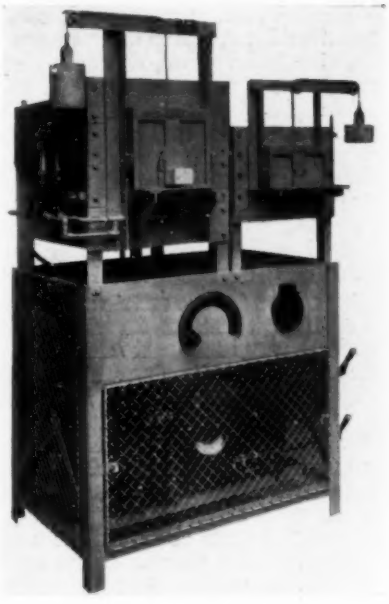
Aluminium has a high intrinsic reflectivity to light and heat, but the use of the metal for reflectors previously has been limited partly by its tendency to loose its high reflective value in course of time and because it could be easily scratched when cleaned. The ordinary hard anodic film provides a means of protection from tarnishing and scratching, but unfortunately decreases the reflectivity of aluminium. Recent discoveries have enabled the British Aluminium Co., to develop a process which combines the advantages of anodic treatment with an actual increase of reflectivity as compared with polished aluminium. "Brytal" treated aluminium shows a reflectivity for light of 85%, compared with 100% for standard silvered glass, 96% for silver plate and 70% for nickel plate. These figures are for freshly polished surfaces and over the visible light range, and it should be remembered that after comparatively short exposure to the atmosphere, the reflectivity of silver and nickel may be reduced substantially. With the treated aluminium reflector no appreciable reduction has been observed after tests under the most stringent conditions.

Treated aluminium reflectors also are superior for heat reflection, the special surface employed being unaffected by temperature and also offers great resistance to the action of gas fumes. It has been found that even though these reflectors are heated almost to the melting point, no diminution of their reflectivity occurs.

The special light-reflection unit and the specimen reflector samples in various metals shown, if examined, will clearly demonstrate the advantages of the "Brytal" process and point the way to the attainment of greater efficiency and economy in reflector design and service. A number of aluminium reflectors by the Benjamin Electric, Ltd., are also shown, and it should be noted that the overhead lighting of the stand has been carried out by the same company with fittings employing reflectors of aluminium.

The importance of "Aldural" sheet metal especially for aircraft work which requires the strength of Duralumin and superior resistance to the action of sea water and other corrosive action, is now well known and a partially broken-down slab of this material has been prepared and etched to show the sandwiching of Duralumin between the layers of pure aluminium. The introduction of this material by Jas. Booth and Co., has permitted considerable progress to be made in seaplane design and construction. It also is finding increasing use for many industrial purposes.

A new development by the British Aluminium Co., Ltd., is shown by several specimens of extruded sections in the company's standard alloys coated with pure aluminium.



Wild-Barfield high speed steel hardening equipment.

Large continuous chain conveyer type electric furnace, for heating aluminium alloy billets, by G.W.B. Furnaces.

This is of particular importance under those conditions where the superior mechanical properties of the standard alloys are required as well as the better resistance to corrosion of pure aluminium.

Two noteworthy exhibits are shown at the rear end of the stand. The first of these is a 2-metre sphere used by the Metropolitan Vickers Co., in their high-tension testing laboratory. It has been produced by spinning in two halves and welding, and is remarkable for the close tolerances to which this work was done by the London Aluminium Co., Ltd. The second of these also has been produced by the same firm and is a complete fairing ring for the Armstrong Siddeley " Tiger " aircraft engine, constructed almost exclusively of aluminium and Duralumin.

Among the interesting examples of pressure and gravity-die castings shown, may be mentioned the component castings for and assemblies of a Hoover vacuum cleaner and a Hotpoint wringer, the castings themselves being the work of Fry's Diecastings Co., Ltd. Among those provided by the Birmingham Aluminium Casting (1903) Co., Ltd., should be noticed the gravity die-cast washer gyrator and pressure-die castings for juice extractors, bacon slicer frame and other purposes. All these have been run in high-content aluminium alloys, that of Birmal being known as their " P-2 " alloy. For certain purposes zinc-base diecastings are commonly used, and several examples of such work are shown. The content of aluminium in alloys of this latter class is quite small, but its inclusion has been instrumental in the successful production of such castings. The volume of this business is such, however, that the annual tonnage of aluminium sold for zinc-pressure and gravity-die castings is very considerable.

Anodising is of particular importance at the present time for industrial, chemical, aircraft, architectural, decorative and domestic purposes and for the latter three, the film is often dyed. In the former applications, its function is essentially protective and dyeing is not usually adopted. The display arranged cannot show every purpose but has been devised to show important applications in each field, and of the several processes available such as those of alumilite, the Aluminium Protection Co., Ltd., and British Anodising, Ltd. One particularly interesting example is the section of an Duralumin spar for a bomber by Handley Page, anodised by the Bengough process. It should also be mentioned that the anodising of the stand offices and the tubes for the columns of the fascia has been carried out by the Aluminium Protection Co., Ltd.

A very fine sectioned example of the Bristol Aeroplane Company's " Pegasus " engine for aircraft is shown, which has, through its exceptional design and performance, earned for itself a unique position in both civil and military aviation throughout the world. Inspection of this engine will show that aluminium and its alloys have been used extensively in its construction, a particularly interesting example of this being the forged " Hiduminium " alloy crankcase. A number of aluminium-alloy forgings and parts, produced by the Bristol Company, are also shown.

The feature of Stand No. D 725/624, which Reynolds Tube Co., have designed to represent a modern airport building, complete with model airplane and the familiar " wind sock," is the light alloy extruded sections which have been used in the construction, showing interesting examples of constructional utility. High-strength aluminium alloy extruded sections in great variety are shown in the well-known Hiduminium R.R. alloys. Many of the sections are used for highly-stressed aircraft components, and show remarkable ingenuity of design to reduce weight and cost.

For the first time I.C.I. Metals, Ltd. (Stand No. D 503/402) are showing aluminium alloy in various forms. They are manufacturing this material in response to an increasing demand from the air, rail and transport industries, and the alloys produced comply with the latest B.S.I. and D.T.D. Specifications. This Company is on the Air Ministry list of approved suppliers for this material.

Copper and its Alloys

Brass, copper and other non-ferrous alloys are shown in plates, sheet, strip, wire, rods and sections, and an interesting exhibit is that of an all-welded locomotive firebox. I.C.I. Metals make firebox plates of all sizes and designs, throat plates of intricate shape, and being equipped with specially wide rolls, they can deal with the largest wrappers used in the locomotive. Copper expansion jointing is being used increasingly—as it is simple, efficient and cheap—for road work, bridge work, and such constructional jobs involving large expanses of concrete.

The " Broduit " copper conduit system, developed since last year's Fair, has made considerable progress. This type of system is cheaper than steel, and cannot corrode. It saves weight and has definite mechanical and electrical advantages over steel. Another development of this Company, " Everdur," a copper-rich alloy of copper, silicon and manganese, which is suitable for the manufacture of storage tanks and heaters, and for use in train sheds, smoke and soot washers, and battery rooms, where smoke and

Atritor unit coal pulveriser with furnace, by Alfred Herbert Ltd.

acid fumes quickly destroy ferrous metals, is being increasingly used. It combines the strength of steel with high resistance to corrosion at a reasonable cost, and also has peculiar advantages for the production of electrical switchgear.

Other exhibits include cupro-nickel condenser tubes such as have been supplied for all new construction in the British Navy since 1926, and for R.M.S. *Queen Mary*, "Alumbro" (aluminium-brass) condenser tubes as were supplied by the company for S.S. *Orcades*, *Orion*, etc., and sundry manufactures of the Company including Kunial alloys, copper rollers, and copper-singe plates.

Despite the progress made with ferrous and other non-ferrous metals the demand for various forms of brass and bronze materials continues to increase, and one of the most imposing ranges of products of this character is displayed by McKechnie Brothers Ltd. This Company show standard alloys for extrusion and stampings; extruded rods and sections in various brasses, bronzes, white metal and copper; solid metal pressings and stampings; chill-

Gas-fired soft-metal melting pot, by W. C. Holmes & Co.

cast bars; ingots in gunmetal, phosphor-bronze type metal, terne metal, coating metal, yellow brass, manganese copper, nickel silver, aluminium alloys, die-casting alloys and anti-friction metal. Production is under the supervision of a staff of metallurgists, whose analytical and physical tests maintain uniformity and soundness in the metals supplied. The purpose of many of the extruded bars on view will be readily appreciated by the visitor, but other shapes will probably be incomprehensible; it should be realised, however, that these shaped bars in brass, bronze, etc., are the raw material used in a wide range of industries which find that extruded bars offer economical advantages.

A prominent display of non-ferrous metals and alloys is given by the Delta Metal Co., Ltd., on Stand No. D 401. Extruded rods in almost every conceivable shape and size and in a great variety of alloys, differing widely in their application, form the basis of the display. Many architectural mouldings are included, both in the Company's "Delta" bronze No. IV. and in "Delta" No. II. silver bronze—this latter being the material in which a large portion of the interior decoration of the R.M.S. *Queen Mary* was carried out. Specimens of "built-up" sections by the use of which large surfaces can be covered with metal for decorative purposes are also shown. These sections are ingeniously contrived, one portion of the edge of a bar dovetailing into its neighbour in a neat manner, the joins being concealed in the lines of the moulding.

The requirements of the engineering trade are catered for by "Delta" bronzes, Nos., I, III, IV, etc., which have great strength combined with high resistance to corrosion. In addition to the usual forms of rods, bars, etc., examples of forgings for marine and other purposes—pump rods, shafts etc., are also shown. This Company has facilities for turning out forgings of all descriptions up to the largest sizes in various of the "Delta" bronzes, naval brass, yellow metal, manganese bronze, etc. For the brass-stamping trade, round, flat and special sections are furnished in "Dixtampo" brand rods for hot stamping, the consistent quality of which is one of their principal recommendations.

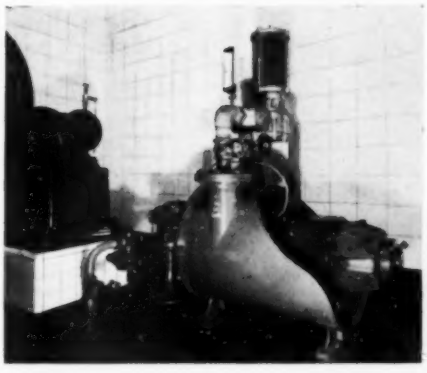
Testimony to the wearing and corrosion-resisting properties of "Delta" bronze, No. IV, is shown in two-pump rams exhibited on the stand which have had more than 25 years continuous use—*i.e.*, 24 hours per day—in water, rapidly attacked and honeycombed ordinary brass and gunmetal.

Another interesting application of this alloy is for the manufacture of ladders for docks, wharves, reservoirs sewerage disposal works, etc., where its non-corroding properties are of particular value.

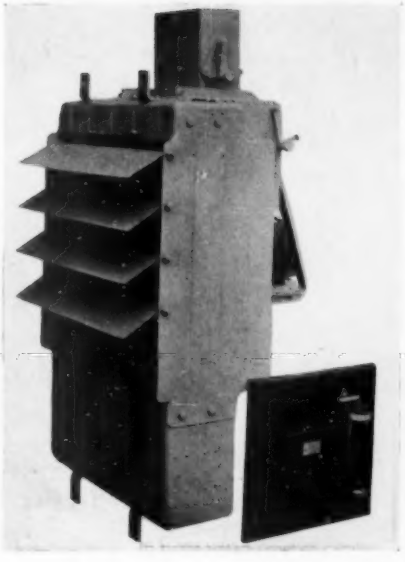
A wide range of non-ferrous metals and alloys are displayed by Enfield Rolling Mills, Ltd., on Stand D 419. These represent rolled, drawn and extruded semi-finished products which are exhibited in the form of sheets, coils, circles and sections produced from copper, brass and zinc. Barker and Allen, Ltd., manufacture a range of nickel-copper-zinc alloys, having a nickel content ranging from 45–7%, and display a coil of each grade in this range, together with phosphor-bronze, copper and brass. This Company specialise in metals for the telephone industry, and nickel-silver, phosphor-bronze and brass made to specification for this industry is on view. What might be termed speciality metals are also manufactured by Telegraph Construction and Maintenance Co., Ltd., who exhibit their "Telcon" metals. These include "Mumetal," "Radiometal," "2129 Alloy" and "Rhometal," which have high magnetical permeability and low electrical losses. This Company also exhibit samples of "Calomic" and "Pyromic," heat-resisting alloys with high electrical resistance. The samples on view show that these metals can be obtained in a comprehensive range of worked sections, such as hot- and cold-rolled sheet and strip, cold-drawn sections, wire and forgings. In the magnetic alloy section samples of welded boxes and screens for magnetic shielding, stampings and made-up transformer cores are shown together with a range of manufactured instruments

embodying these alloys in their construction. The heat resisting alloys are shown as wires ranging from $\frac{3}{8}$ in. down to 0·001 in. Samples of both bright annealed and oxidised wire are on view. The exhibit also includes articles welded from sheet showing the adaptability of these alloys for furnace parts and pyrometer tubes.

The products shown by Johnson Matthey and Co., Ltd., on Stand Cb 312, include a range of special silver-brazing alloys and silver solders, together with some indications of their industrial applications. Other products include oxides, used in the sheet metal industries for enamelling iron; and contact bi-metal, which is gaining increasing popularity in the electrical trades. Two brazing alloys which are worthy of particular attention are "Easy-flo" and "Sil-fos." The latter has been widely used for some years now, and is extremely popular for making sound and reliable joints on brass, bronze and copper. Its consumption is still rapidly increasing, which is certainly evidence of its growing popularity as a brazing alloy. "Easy-flo" is a comparatively recent introduction, and gives excellent results in the making of joints between dissimilar metals, such as brass to steel, Tungum to steel, etc. It can be used, without difficulty, on brass, bronze, copper, Monel metal, nickel alloys, Tungum, and all grades of steel (including stainless steel).



Gas carburettor supplying gas-air mixture of constant proportions to immersion burners, by W. C. Holmes & Co.



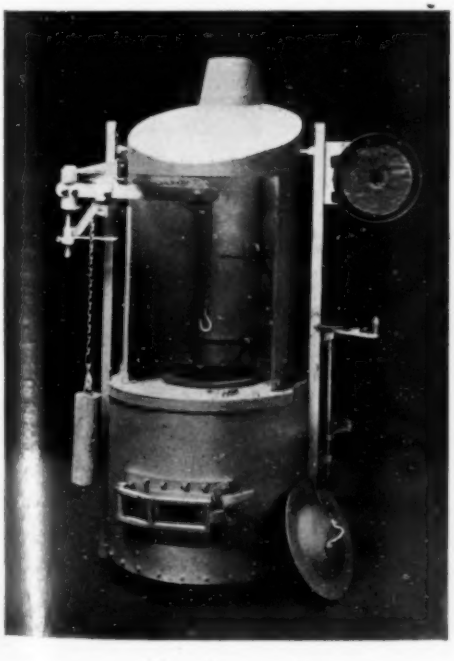
"Serek" gas-fired unit heater.

Heat-Treatment Furnaces

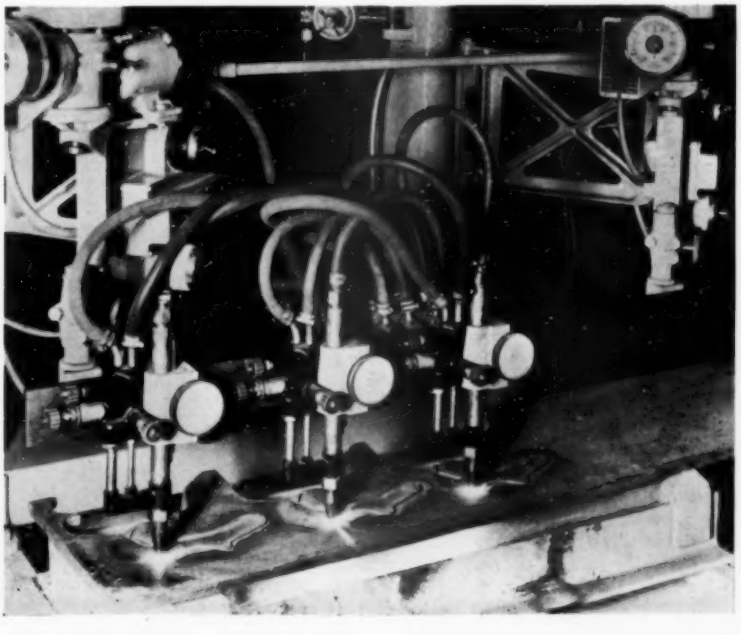
In metal working, the process of heating is only one item of cost, but the effect of that item is felt in other items of production and cost. Material which is not uniformly heated, or which is burned or oxidised, either wholly or in part, causes losses due to rejection after much work has been put on the material. In the process of heating, in which high quality and low overall costs are primary considerations, furnace design, burner design, selection of source of heat energy, and heating methods are important factors, all of which must be considered as contributing to the final result. Many factors, therefore, affect the selection of heat-treatment equipment, and hundreds of different designs of fuel and electric furnaces have been developed to meet the wide range of requirements in heat-treatment work. Recent years have seen considerable developments in controlling the heat required in a furnace, in controlling the atmosphere and in general making the heat-treatment furnace a scientific tool with which each operation is so controlled that as little as possible is left to the human element.

There are few engaged in engineering who are not, in some way, connected with the heat-treatment of materials, and considerable interest is, therefore, attached to the heat-treatment equipment displayed at Castle Bromwich. Some of the most modern plant is on view, while in other

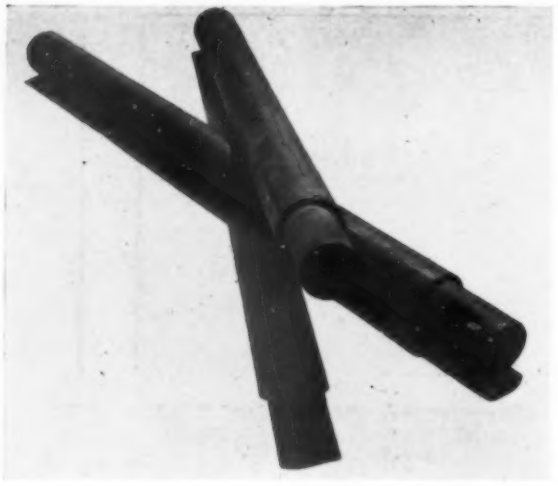
Salt bath gas-fired furnace by I.C.I. Ltd.



Triple cutter universal cutting machine in operation, by British Oxygen Co.



Wharf and dock ladders in Delta Bronze No. IV.



Pump rams made in Delta Bronze No. IV., after more than 25 years' service in water which rapidly attacked brass and Gunmetal.

instances large furnaces are represented by photographic displays. In some instances firms specialise in the design and construction of furnaces to use a particular heating medium, one of the exceptions is I.C.I., Ltd., who show on Stand D 306 a number of salt-bath furnaces heated by oil, gas or electricity, for all ferrous heat-treatment purposes. Specimens of heat-treated steel are shown and visitors are invited to bring samples of their products for hardening.

The chemicals used in these furnaces are "Carboneutral" "Rapideep," cyanide, and tempering and heat-treatment salt. "Carboneutral" is an alkaline-earth bath, specially designed for the hardening of high-speed steels. The hardening of these steels calls for treatment at elevated and accurately controlled temperatures. Normally, these can only be achieved at the expense of more or less severe oxidation of the steel, but the "Carboneutral" bath effectively protects the steel against oxidation or other alteration in composition. Cyanide is used for light case-hardening and heat-treatment. "Rapideep" is used with the ordinary case-hardening bath, but the case-depths obtained, besides being deeper than those conferred by a cyanide bath have the advantage of being glass hard for over half their depth, as compared with a third with cyanide.

The Incandescent Heat Co., Ltd., is another firm who manufacture furnaces for all fuels and all processes. A block of offices has been taken for themselves and their associated companies, Metalectric Furnaces, Ltd., The Selas Gas and Engineering Co., Ltd., and Controlled Heat and Air, Ltd. They occupy Stand D 327/226, where a comprehensive range of manufactures is illustrated by photographs which visitors will find of interest. A full staff of technical representatives is in attendance for consultation on furnace problems, and arrangements can be made to visit the works at Smethwick.

On Stand D 404 Alfred Herbert, Ltd., exhibit the Atritor unit coal pulveriser and the iron fireman coal-burning stoker. A No. 6 Atritor is on view, having a capacity of 500 lb. of coal per hour, operating three small furnaces suitable for forging. The advantage of the system is that one Atritor can be used for firing as many as fourteen or more furnaces, each having independent and precise control. The amount of coal passing to each furnace is controlled by a valve, so that the furnace can be maintained at any desired temperature without affecting other furnaces in the line. This type of pulveriser is applied successfully to reverberatory furnaces, reheating furnaces, low-temperature furnaces for annealing steel or malleable iron castings, cold-rolled strip and the heating of hot pressings,

Electric Furnaces

It is, of course, impossible for any individual firm to show all the various types of furnaces they manufacture, but Wild-Barfield Electric Furnaces, Ltd. (Stand C b403/302) show a very wide range, all of which are in operation. The equipments vary from small laboratory muffles up to industrial equipments for high-speed steel hardening, carburising, etc. Two furnaces are included equipped with this firm's patent "Heavy-hairpin" heating elements, one a horizontal box type and the other a vertical furnace. The former is for use as a carburising furnace, although the general details of furnaces for other treatments are not very different. A large number of vertical "Heavy-hairpin" furnaces are in use, but this is the first time one has been exhibited. Vertical furnaces for hardening, etc., are very frequently better adapted for the purpose than horizontal equipments, particularly where the work would be liable to distortion if laid on its side.

Two sizes of vertical forced air circulation furnaces are shown. These are fitted with Wild-Barfield patent centrifugal fan, which gives a very rapid air circulation even with a dense charge. One of these furnaces is for tool-room and experimental use, whilst the other is a larger production model. This is fitted with a charge-progress recorder, for controlling the furnace temperature, and also recording this temperature and that of the charge. This is a very valuable feature and saves much time as the operator is immediately informed when the charge has attained the desired temperature. There are also two electro-magnetic hardening furnaces on view. When carbon and low-alloy steels require hardening, these furnaces give excellent results, as they determine exactly the non-magnetic point for the steel, which, as is well known, is the correct instant for quenching to obtain the finest grain structure with hardness. Many small muffle furnaces are shown including the vertical and horizontal types, together with tube furnaces for combustions, thermo-couple checking, etc.

High-speed steel hardening equipments are represented by two sizes. A small equipment for general tool hardening and any small work will be shown. In this the high-temperature chamber is mounted above the preheater on a common stand. The larger equipment consists of two entirely separate units. The preheater is one of Wild-Barfield "Hairpin-minor" furnaces, which were introduced fairly recently and which besides their use as preheaters, are now being widely used for many other forms of heat-treatment such as annealing, hardening, normalising, carburising, enamelling, etc. Both the high-temperature and preheating furnaces are fitted with automatic-temperature control and with their "Counterscale curtain" for providing positive control of the furnace atmosphere, which enables scale-free hardening to be carried out.

The electric furnaces manufactured by G.W.B. Furnaces, Ltd., are of two large a nature to permit them being shown, but a series of photographs illustrating furnaces recently erected are worthy of notice. Attention is directed to a large continuous chain conveyer-type furnace, for heating aluminium alloy billets, prior to extrusion in the form of tubes, light sections, etc. This is one of the largest electric furnaces of its type in this country, the large billets weighing 7 cwt., and the furnace holding 20 of these at one time. Every operation entailed in the use of this furnace is automatic, and after the billets are rolled on to the hoist they are not touched again by hand until after extrusion.

Others include a bell-type furnace for bright annealing wire at temperatures up to 1,100° C., in a protected atmosphere obtained by the introduction of a suitable gas; an electric furnace, the first of its kind to be made in this country, for continuous wire patenting. The furnace works at temperatures up to 1,000° C., and is divided into four separately controlled zones. A maximum of 20 strands of wire are accommodated in the furnace at one time. An interesting furnace is a continuous type slat conveyer furnace for annealing cast-iron motor-car pistons prior to machining; a roller hearth hearth furnace, used for the heat-treatment of aluminium billets prior to forging, stamping, etc., is another example, together with two charging machine-type box furnaces, which are used for annealing coils of brass and bronze strip, which will prove interesting.

In accordance with the principle which Birmingham Electric Furnaces, Ltd., initiated last year, their stand is arranged mainly as a technical information bureau on electric furnace practice, where this company's engineers can discuss with prospective users both the characteristics of electric melting and heat-treatment furnaces in general, and the performance of the many " Birlec " designs available for special purposes. Here, again, a prominent display is made of photographs showing actual installations of every type, including some of the largest electric furnaces in the country.

Certain types of " Birlec " furnace will be represented by scale models, the full-size equipment being too large for exhibition. A special type of internally-heated salt bath, with removal elements, for the heat-treatment of aluminium alloys and improved design in the well-known Birlec-Detroit rocking, indirect arc-melting furnace are featured. Many of the smaller furnaces, however, will be in actual operation at this company's demonstration department, about one mile distant from the Fair, where facilities will be provided for practical tests on bright annealing, scale-free hardening and general heat-treatment and melting work. Typical products from " Birlec " heat-treatment and melting furnaces will be exhibited on the stand for the purpose of demonstrating the extremely high standard of quality and finish obtainable in various processes.

Gas Section

The gas section is larger than ever before, and includes exhibits by most of the important manufacturers of domestic gas appliances. Some 75 firms are exhibiting. The whole of the arrangements have been made by the national bodies of the industry. During the period of the Fair a conference of the whole of the gas industry will be held on Tuesday, Wednesday and Thursday, February 23–25.

The British Gas Federation has organised a joint industrial exhibit which comprises a representative display of industrial equipment, most of which will be in actual operation. One of the most interesting sections of this exhibit is concerned with modern directional factory-heating equipment. Three types of appliances are shown—high-temperature radiant panel, medium-temperature radiant panel, directional unit air-heaters. The radiant-heating panel can be used to heat the area in which a man works without heating the whole of the shop, thereby providing a most economical method of heating a large works, for the heat necessary to warm all the area of the building would be out of proportion to the heat required to warm the immediate surroundings of each workman.

The high-temperature radiant panel consists of a porous refractory brick, and the gas is made to burn in the pores of the brick, thus heating it to incandescence without visible flames. The medium-temperature panel consists of an inclined mild-steel plate finished in black-vitreous enamel, and heated by gas burners from behind. The directional unit air-heaters consist of a fan blowing air over special steel tubes, each heated by a gas burner, through adjustable louvres, which direct the heat towards the place where heat is required.

There is also a die-casting exhibit. Aluminium alloy will be melted in a gas-fired furnace, and motor-car pistons will be made in a die-casting machine. In addition to various other types of gas-fired, non-ferrous metal-melting furnaces, there will be a number of low-temperature ovens for heat-treating non-ferrous metals within the unusually close limits required for modern alloys.

Of particular interest is a new stereo-metal melting pot in the industrial exhibit. In this the gas burners are actually inside the molten metal—instead of being below the pot—thus minimising heat loss and avoiding all trouble with burnt pots. The secret of the new design lies in a mechanical mixer, which delivers an accurately proportioned mixture of town gas and air to the burner. The latter is housed in a steel tube shaped like an inverted " P," of which the loop part is below the level of the molten metal.

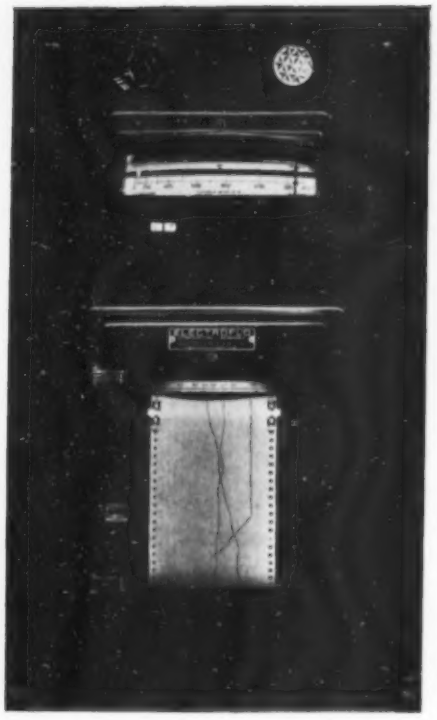
Ether endwise pyrometer.

Ether automatic temperature recorder.

As usual, there is a complete working heat-treatment shop where visitors can see demonstrations and, if they like, have their own work heat-treated. Of particular interest is the atmospheric-controlled high-speed steel-hardening furnace, in which high-speed steel can be heated to 1,350° C. without appreciable scaling or decarburisation.

Oil Burners

Of many types of burners on view the " Rotavac," a burner for heavy oil fuel, is of interest. It is manufactured by Nu-way Heating Plants, Ltd., and is suitable for all types of furnaces. It has exceptional atomising properties which ensure highly efficient combustion of heavy fuel oil, resulting in maximum heating efficiency from oil consumed, ease of ignition, the elimination of carbon deposit in the combustion chamber, or on the burner itself; facilitates the control of furnace atmosphere, and prolongs the life of refractories. This burner is largely used on fuel oil of 200 secs. viscosity, which is generally available at a lower price than lighter oils, but it may be used on oils of much lower viscosity without preheating.



Electroflo single-point motor-driven recording pyrometer.

Ether "Ludicorder."

The jet in this burner is so shaped and positioned that the oil is discharged from it into a high vacuum. This vacuum is obtained at the vortex created by the rotational velocity of the air in the burner itself, and gives a high velocity of discharge to the fuel issuing from the jet. Moreover, this velocity is proportional to the air velocity, so that when arrangements are made, as explained later, to ensure that the oil does not have an initial velocity at the jet, the oil quantity will be proportional to the air quantity. The burner can therefore be arranged to give the correct ratio of oil and air for all flame sizes merely by controlling the air valve. This is of particular value in installations where automatic control or complete simplicity of hand operation is required.

Testing and Testing Equipment

Of considerable interest is the display by Industrial Research Laboratories, Birmingham Gas Department. On Stand D 721 the machinery and apparatus exhibited show on a small scale the equipment of the laboratories at the Council House, and give an idea of the work which can be carried out for engineering and industrial firms and those interested in building operations.

The exhibit comprises a 50-ton self-indicating universal testing machine; a testing machine specially designed for taking smaller specimens than the above; a Brinell hardness testing machine, in which the load is indicated on weighing levers; a hardness testing machine fitted with a dial for giving direct-hardness test results; a 120-ft./lb. impact testing machine of the Izod type; apparatus for determining the cupping properties of metals; a hand-operated spring testing machine for dealing with small, and medium-sized coil springs; and a fatigue testing machine of the Wohler type. These machines and pieces of apparatus have been loaned to us by Messrs. W. and T. Avery, Ltd.

A collection of smaller pieces of apparatus usually associated with laboratories, and dealing with measurements of humidity, stress, vibrations and sizes of articles, have been loaned by the Cambridge Instrument Co., Ltd., and other scientific instrument makers. The apparatus and machines can be demonstrated when required, and arrangements have been made to carry out tests, without fees, for other stand-holders' material during the period of the Fair.

Degreasing Plants

The I.C.I. have this year modified their range of degreasing plants, which are now available in a range of standard sizes and in three types, in addition plants are supplied to any required capacity in each type. These degreasing plants are in continuous use throughout industry, being used to treat all types of metal products, from fish-hooks and trouser buckles to torpedoes and fuselages. They are designed for hand-operation, as automatic integral units, or, quite frequently, they can be adapted for installation in an existing conveyer line. They remove greases, oils, waxes and resins. They cover a wide range of requirements from cleaning dirty machinery to producing chemically clean surfaces for critical finishing operations, such as plating, enamelling, parkerising and bonderising.

The solvent used is trichlorethylene. The most powerful of grease solvents, it has the added advantages that it is non-inflammable, free from any detrimental action on any metal, leaves a dry, neutral surface, and is separated from the oil and greases removed from work by simple distillation apparatus incorporated in all machines. When a few simple precautions are taken the process is completely safe. The plants exhibited are on Stand D 405, and all are in operation. A polishing unit is also shown in operation, and demonstrations are given of the polishing of work and subsequent removal of oil and polishing compound in the degreasing plant.

Temperature Control Equipment

Much of the progress associated with heat-treatment furnaces can be credited to subsidiary equipment and appliances which are now regarded as essential to the proper use of the furnaces. These refer to indicating, recording and automatic temperature-control equipment, many examples of which are on view. For instance, included on the British Gas Federation's Stand, Ca 709/608, is an Electroflo indicating, recording and automatic temperature-control equipment applied to an atmosphere-controlled jobbing drill furnace of the Sheffield Gas Company's type. It is arranged to control and record the temperature of the working chamber (at approximately 1,350° C.), and to indicate the temperature of the preheating chamber (approximately 900° C.). The Electroflo "Longscale" (10 in.) indicating control pyrometer is used, which is a superior model of the original 6-in. scale mercury switch type of control pyrometer, introduced over seven years ago.

An Electroflo single-point motor-driven recording pyrometer provides records of the highest accuracy and legibility on a 6-in. wide, 1,600-hour continuous roll chart. The chart of this instrument is timed and driven by an a.c. synchronous motor, which ensures an ample reserve of power and continuous trouble-free service. Another model is employed to measure the temperature of the preheating chamber, and in common with all the equipment is of robust construction, having been specially designed for industrial use. All the instruments are flush-mounted on a floor-mounting cubicle-type steel panel, measuring 3 ft. wide by 6 ft. high by 10 in. deep. A typical panel, carrying a "Longscale" controller and recording pyrometer, is illustrated. The equipment exhibited is equally applicable to electrically heated, gas- and oil-fired furnaces, and under particular circumstances to solid-fuel fitted furnaces.

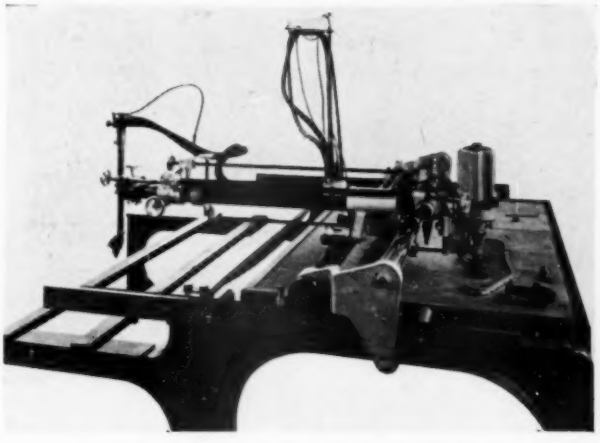
A range of pyrometers and thermometers for the indication, measurement and control of low, medium, and high temperatures is shown by Ether, Ltd., on Stand Cb 817.

Edgewise, round pattern and portable indicators are exhibited ; the prime mover in this range of instruments being a sensitive moving-coil galvanometer, embodying Stevenson's concentric movement (patented). This is fully floating on sapphire jewels to overcome damage to the pivots, caused by any shock or vibration. In these extremely sensitive instruments it should be noted that a power consumption of only 0·00000016 watt is required to deflect the pointer across the full scale. The edgewise indicators are made in three sizes, having scales 5 in., 7 in., and 12 in. in length. The scale is instantly adjustable, so that the pointer position corresponds to the true air temperature. The round pattern indicator is suitable where quick readings of commercial accuracy are required, and it is supplied with a 5-in. length scale, provided with a red pointer, that can be fixed in any position on the scale for the operator to work to. Ether portable indicators are designed for portable testing work, and are supplied with a 5-in. or 7-in. length of scale. These instruments will stand hard usage and maintain their accuracy.

It should be noted that the instrument pointer has no work to do other than that of indicating the temperature, the mechanical selector mechanism and the mercury switch being operated by the powerful electric driving motor. An integral unit of this control pyrometer, and one which is to be recommended for all high-temperature furnaces, is the Electroflo patented broken-thermocouple safety device. In the event of a break in the thermocouple circuit, or if a high-resistance contact develops, the indicating pointer of the control pyrometer rises to the top of the scale and shuts the furnace down. Damage to the furnace and its contents, due to excessive temperature airising from such conditions, is thereby prevented. The mercury switch of this controller operates a reversing motor-driven valve regulator, which, in turn, adjusts the position of the main air supply valve through an adjustable link. The correct amount of gas for efficient combustion is automatically induced by the high-pressure air.

Molten metal pyrometers which are being extensively used are also exhibited by this firm. These instruments can br used for indicating all non-ferrous molten metal temperatures, also low-temperature cast iron, etc. A surface-contact pyrometer is shown used for the surface temperatures of aluminium-alloy billets, etc., when being forged or rolled. This instrument consists of a portable millivolt meter, self-contained, with a thermocouple holder. The thermocouple is in the form of two spikes, terminating in points, that have little heat capacity, and thus an instantaneous reading is obtained when they are pressed against the surface to be measured. The range of this instrument is up to 800° C. The " Indicorder " continuous chart-recording and indicating pyrometer is shown in operation. Synchronous motor driven, this unit will give a record of furnace temperature for one month without attention. Another interesting feature is the Ether automatic temperature controller, which is a simple and highly accurate " make-and-break " mechanism that is absolutely positive in action. An application of the control to a gas-fired furnace is shown, consisting of a valve connected to the electric mains via the controller, and operated by the powerful solenoids or a geared motor.

Representative examples of automatic control equipment for space heating, refrigeration, air-conditioning and industrial heating installations are shown by the British Thermostat Co., Ltd. These include thermostats, humidistats, pressure-stats, expansion valves, float valves, magnetic and motorised valves, relays and contractor gear, complete control panels, and numerous smaller components such as bellows, gland-type shut-off valves, and refrigeration accessories. Among devices shown for the first time, two call for special mention. The first is the range of " Teddington " hydraulically operated motorised valves for controlling the flow of steam, water, refrigerants, liquid or gaseous fuel, and the like under thermostatic control. In these units the thermostatic switch, or other



Universal cutting and profiling machine, by Hancock & Co.

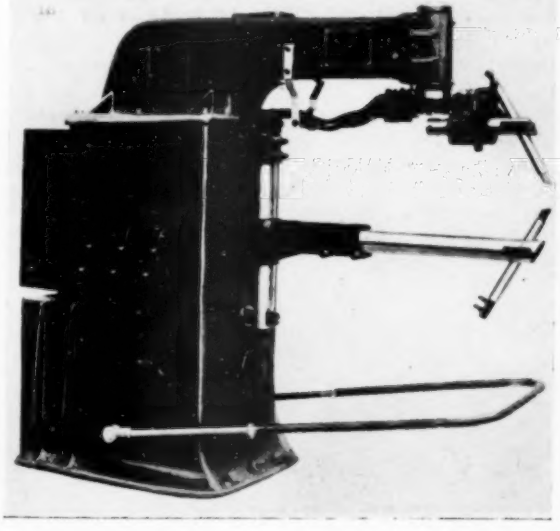
automatic switching device, controls a small electric motor, driving an oil pump, which transfers oil from a reservoir to a bellows chamber, thus setting up hydraulic pressure, which operates the valve through the bellows mechanism, against the pressure of a spring. Visitors from overseas are cordially invited to inspect the display of automatic control equipment, and to establish contact with the members of the technical and sales staff.

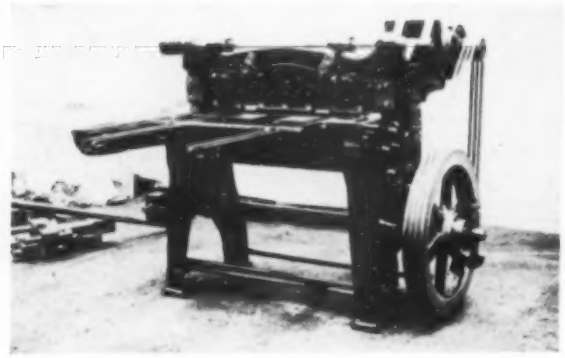
Refractories

The need for high-grade refractories is recognised more to-day than ever, especially in those industries where high temperatures are involved in operations. Almost invariably the best grades are more economical in the long run, although their initial cost may be relatively high. One of the leading manufacturers of high-grade refractories, John G. Stein and Co., Ltd., show on Stand D 403 a comprehensive range of their products, from which materials can be selected for most industrial furnace applications. The excellence of shape and finish, and the accurate dimensions of standard sizes and special shapes alike, are themselves eloquent of the care which is expended in the course of manufacture of these products.

Mention may be made of bricks and shapes for segmental gas retorts, glass furnaces, coke-ovens and steel furnaces in " Myrtle " and " Bluebell " brands, both containing 95% silica ; also the " Nettle " and " Thistle " brands

Fixed head spot welder with universal electrodes, by New Process Welders Ltd.





High-speed shears, by Brookes (Oldbury) Ltd.

which are widely known, particularly in the form of suspended arch blocks and standard bricks, by boiler engineers. An addition is the recently perfected "Nettle N.S.," a quality which is designed to give good service in positions subject to severe thermal spalling. Included in the display are some of the more aluminous products, notably "Stein 80" and "Stein Sillimanite." The former finds its application in positions subjected to extremely high temperature; and the latter, by reason of its desirable structural properties.

For the steel-maker the exhibit holds much of interest. In addition to "Myrtle" silica bricks, will be shown "Stein" ladle bricks, sleeves, nozzles, stoppers, etc., of high quality, blast-furnace linings and special checker and stove-filling shapes, including the J.G.S. and C.O. checker, which has been specially designed to increase furnace efficiency. The range covered by the display is extended by samples of "Stein H.T.I." (high temperature insulation), the usefulness of which in reducing heat loss is being generally recognised, and by a useful range of cements and plastics.

Gibbons (Dudley), are exhibiting a range of refractory materials sufficiently comprehensive to cover the bulk of industrial requirements. 95% silica goods are exhibited in the form of bricks, segmental retorts, and coke-oven shapes, in all of which a high standard of quality and finish has been achieved. An exhibit of great interest in view of the steadily increasing use of hot-face insulation is the Gibbons H.T. 1 refractory insulating brick, combining the high-melting point of a firebrick with very low-thermal conductivity. Fireclay and aluminous materials are shown in a variety of types both as standard bricks and special shapes, whilst sections of fireclay and siliceous gas retorts are also on view. The exhibit is completed by a range of super refractories in silicon carbide, fused alumina and sillimanite materials and refractory cements for various purposes.

General Refractories, Ltd., display basic refractories which include the new Saxpyre brick—the improved basic refractory. This brick combines better spalling resistance with high refractability under load. These improved properties allow a brick to be used in exposed positions with a greater margin of safety, and with greater durability for basic open-hearth furnaces, electric steel furnaces, soaking pits, reheating furnaces and copper smelting furnaces. Of particular interest at the moment is the question of insulation, as it is a means of reducing fuel consumption in furnaces and kilns, a very important consideration.

Plastic refractories, called "Durax," which are exhibited, possess such improved properties that their field of facility has been extended considerably. For instance, the serious tendency of permanent volume charge, which is a fault with most monolithic refractory materials, has been remedied. "Durax" does not shrink on drying, and is unaffected by continued firing. This has been made possible by calcining or preheating the raw materials used and thoroughly shrinking them during the course of manufacture.

Electrical Industries

During recent years considerable attention has been given to street lighting, floodlighting and industrial installations, and the majority of the large electrical companies have outstanding displays with entirely new notes in lighting decorations. These displays are of particular interest in view of the Coronation celebrations as a large number of illumination devices have been specially designed for that occasion. In addition, all the companies are showing a selection of products representative of a few of the many fields in which they are active, particularly the various types of motors and welding sets. One especially interesting feature of the Metropolitan-Vickers Electrical Co., is a group of "Metrovick Electric" battery-operated vehicles. Three chassis sizes are shown complete with commercial-van bodies. These vehicles are motor driven through a transmission shaft and back axle differential gear somewhat similar to motor-car practice, but with the difference that the drive also incorporates a reduction gear of high ratio to allow the use of an economical speed for the motor.

Welding Equipment

Considerable progress has taken place in the welding industry and equipment now available facilitates operation in many specialised products. Among the types of arc-welding sets chiefly in demand are a.c. and d.c. single-operator sets, enclosed in weatherproof cases and mounted on wheels to give portability. Examples of G.E.C. welding plant are shown in operation on this company's stand. In the a.c. arc-welding set the transformer primary can be wound for a single-phase or three-phase supply as required. The secondary gives a striking voltage of 70/80, stability and current control being provided by a choke coil from which tappings are taken to a current-selector switch. Transformer and choke coil are enclosed in an oil-filled tank.

In the d.c. welding set a motor generator is employed, having a single steel shell and a common shaft mounted on ball bearings; the whole set is dynamically balanced so as to minimise vibration. The set is designed to give a maximum of 300 amps. at 25/300 volts for metallic welding and 200 amps. at 45 volts for carbon arc work. A direct-to-line push-button starter is built into the casing, and the current can be varied in very fine steps by means of two regulators, one coarse and the other fine.

Holden and Hunt show a 25-kva. electric spot welding machine designed to meet the needs of present day heavy-duty spot welding; this is for high-speed welding on light sheet steel, with very little foot-pedal travel, yet retaining their toggle-pressure gear, which gives heavy pressure on the weld.

The design of the standard spot welders is thoroughly practical. They are entirely free from any risk of electric shock, and even during the process of welding all exposed parts can be handled with impunity. An automatic trip switch of unique design and having a wide range of adjustment is fitted, the renewable contacts being made from non-arcing metal. The heating speed is controlled by means of a fully-guarded multiple way regulator, whilst the water-cooled electrodes can be fitted quickly and easily with renewable tips of varying shapes to meet different requirements. The electric efficiency is extremely high resulting in the maximum number of welds per unit of current, whilst the complete absence of soldered joints enables the machines to stand heavy overloads without damage. The outstanding feature of these machines is the simplicity and ease of operation, their adaptability and great saving in cost and time. They are controlled entirely by foot pedal, so that the operator's hands are free to handle the job, and the effort required to work the pedal is so slight that the machines can be operated by a boy or girl from a sitting position.

On Stand Cb 221, New Process Welders, Ltd., show a comprehensive range of resistance welding machines. Many of the welders shown have been developed during the last 18 months. The largest welder on view is a 50-kva. pneumatically-operated twin-spot machine, which is fitted with two transformers, and is specially designed for welding large sheets in connection with the manufacture of railway wagons and similar articles. An entirely new machine of particular interest is the 35-kva. pneumatically-operated fixed-head spot welder, fitted with universal electrodes and with a novel style of vertical bar fixing for the lower arm. The well-known 8-kva. spot welder is also shown together with a pneumatic conversion set, with the use of which the machine may be used as a single spot welder or a stitch welder, the welds being automatically controlled in each case.

Arc-welding equipment of the single and multiple-operator type for both portable and stationary use, is shown on Stand D 324 by The British Oxygen Co. The equipment includes a single-operator a.c./d.c. motor generator, having a current range of 15/150 amps., also a double-operator motor generator set with regulators to give a current range of 60/220 amps. per operator. These machines are of unit construction, having a combined frame for both motor and generator, while the armatures are mounted on a common shaft supported in ball and roller bearings. This method of construction reduces the floor space to a minimum and makes a very neat and compact arrangement. In addition to welding plant the Company exhibit and demonstrate the ferro-arc range of electrodes which includes varieties suitable for practically all requirements of the engineering trades.

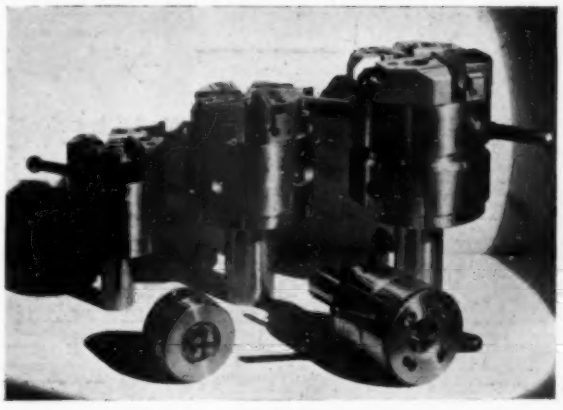
The oxy-acetylene exhibits of the British Oxygen Co., are on the main Stand D 511/410, here the familiar types of regulators, blowpipes, cutters and other accessories, equipments and materials manufactured and supplied by the company are exhibited and demonstrated. This year, a 20-in. multi-head oxygen cutting machine is shown in operation as well as joist, straight line, and 55-in. oxygen-cutting machines. Stack cutting, double-vee cutting, vee-slot cutting and the cutting of flanges from rails will all be shown in addition to oxygen machining. The accuracy of stack cutting is demonstrated by the engagement of six gears which have been produced simultaneously by means of one templet.

A roll, having the wobbler end and neck built up with cast iron deposited by the oxy-acetylene blowpipe, is exhibited to illustrate the utility of the oxy-acetylene welding process for reclaiming worn parts. The use of stellite is exemplified by the exhibition of a steel cement conveyer screw having the worn screw partly built up. Visitors can thus see the extent of the wear experienced, and the nature and utility of such a deposit.

Three oxygen cutting machines are exhibited by Hancock and Co., Ltd., a universal " Simplex " profiling machine, a " U " arm type profiling machine, and a " Circaline " portable straight-line and circle cutter, all of which are shown in operation. The universal machine has a cutting area of 60 × 40 in. in metal up to 8 in. in thickness, and is fitted with universal electric tracer embodying four interchangeable forms of drive, thereby enabling the machine to operate direct from a drawing, direct from a template of strip aluminium, direct from a wooden template and from a channel template.

Forging Machines, Presses and Shears

Although the forging of metals is probably the oldest branch of mechanical engineering, the improvements and possibilities of modern forging are not, generally speaking, well known amongst engineers and manufacturers; for this reason a visit to Stand D 413, occupied by Greenwood and Batley, Ltd., will prove interesting and informative. Forging machines are now essential where large production of forgings is required, and it is surprising how wide a range of products can be produced. They are not only highly productive machines, but the degree of accuracy of the product is such that following operations are simplified and economical.



Some types of " Herbert " diehards.

Among presses of various types exhibited those of Taylor and Challen will attract attention. One of these is a crankpress for hot brass presswork of 100 tons capacity, and with 8-in. stroke. It is used chiefly for the production of extruded articles, the dies being so made that the hot billet is totally enclosed in collars before the punch strikes it in its descent, so that no flash escapes; these collars are capable of movement, the bottom one usually being supported by a stiff spring, which also serves as a bottom extractor. A top extractor and bottom extractor worked off the slide of the press are also fitted. The press is geared, and arranged to run at 60 strokes per minute. A notching press for stator rings of electric motors is shown. This is specially designed for internal notching at high speed.

Brookes (Oldbury), Ltd., exhibit a number of improved shears on Stand D 322. A high-speed geared type has a capacity of 6 ft. by $\frac{1}{8}$ in. mild steel, which is arranged for direct electric drive. This machine is fitted with positive cam-operated holddown, special vertical adjustment to the bottom blade, and a screw-operated back gauge, designed so that both screws can be operated simultaneously or independently, as desired. The locking is positive, and prevents any " creep " taking place when the back gauge is in use. It is also fitted with a new type automatic tripping device to the clutch for continuous working. The device can be usefully applied to finishing shears in sheet mills, where cutting takes place in regular sequence, and also for cutting up narrow width strips using the back gauge. Further, it has an application to power presses for certain classes of work.

Another machine on view, a high-speed undercrank type ungeared precision shears, has a low blade rake, and is suitable for very accurate shearing. It is fitted with positive type cam-operated holddown, and the holddown gate is provided with pads of wide area, covered with red fibre and compensated with rubber buffers. A special squaring arm is fitted with a straight edge, provided with means of adjustment so that it may be maintained square with the cutting edge of the blade.

Electroplating and Metal Finishing

Developments in equipment for electroplating and metal finishing are shown by Messrs. W. Canning and Co. On this stand is an electro-plating vat, showing the latest method of filtration of the plating solution. The apparatus includes a seven-pot filter unit, special pumps and air compressor, and ebonite agitator pipes. A metal plate 500-amp. rectifier for coverting a.c. to d.c. current for electroplating is connected to this exhibit, and the whole will be in operation filtering 200 gals. per hour.

(*Continued on page* 131.)

Reviews of Current Literature

Tungsten

SINCE the publication of the first edition of this valuable book in 1926 there has accumulated considerable further information, not only regarding the properties of the metal, but also in connection with its industrial applications, and, in consequence, this second edition issue is nearly twice the length of the original volume. New determinations of the physical properties of tungsten over a wide range of temperature have made available much more accurate data, the reliability of which has been ensured in many cases by interchange between the national standardising laboratories of Europe and America.

As a result of the further study of tungsten, greater control is now possible over the structure of tungsten filaments; in addition, several new industrial applications of the metal have been developed, of these probably the most important is the development of tungsten-carbide cutting tools. A number of non-ferrous tungsten alloys, in which tungsten is a major constituent, have also made their appearance, and important improvements in both the mechanical and magnetic properties of tungsten steels have taken place. The most important of these developments are incorporated in this volume, and in its present form the book has an increased practical value. As a treatise on the metallurgy, properties and applications of tungsten this book can be regarded as a standard book of reference.

By COLIN J. SMITHELLS, M.C., D.Sc.; published by Messrs. Chapman and Hall, Ltd., 11, Henrietta Street, Covent Garden, London, W.C. 2. Price, 25/- net.

Hardness of Metals

To the engineer the physical properties of materials are of great importance, because the forces acting upon a mechanism would destroy it by distortion or fracture if the strength did not correspond with the particular stress imposed. It is therefore necessary to know the nature, direction and the intensity of the forces acting upon every element in a mechanism; but the capacity of the material to resist these forces without distortion or fracture is of primary importance. It is for this reason many and varied tests are applied to materials in order to determine their relative resistance to forces, so that when the amount and distribution of the stress in an element is known its resistance can be calculated. Among the properties of metals and alloys which are significant, few exceed that of hardness in importance; yet this property is very indefinite, and no satisfactory definition of it has been given.

In this work the author makes no attempt to define the property of hardness, but a number of methods have been developed for determining comparative or relative hardness, which are of great service in practice, and he endeavours to determine fundamental relationships between the methods in most common use. It seems that in determining this property practice has outstripped theory, because there can be no doubt that the various hardness tests have proved of great value for controlling the quality of both ferrous and non-ferrous metal products.

The principal object of the author has been to establish relationships between indentation, pendulum and scleroscope tests, and to make it possible within certain limits of accuracy to obtain readily the corresponding hardness numbers as determined by these methods. For this purpose a long series of tests have been carried out, the results from which are shown in the form of curves, and, finally, a chart, by which it is claimed to be possible to read simultaneously the hardness numbers from the various machines.

This is a thought-provoking book on the property of hardness, and the author has done useful service in dealing with such an involved subject in such a painstaking manner. All who have given serious thought to the determination of hardness will find this book interesting and informative.

By F. C. LEA, O.B.E., D.Sc.; published by Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price, 12/6 net.

Duralumin and Its Heat-treatment

THE rapid development in the use of aluminium is undoubtedly due to the fact that many of its alloys are susceptible to heat-treatment. A systematic study of the underlying causes led to the development of a large number of alloys whose properties could be controlled within useful limits. Of the many aluminium alloys which attain their maximum mechanical properties after suitable heat-treatment, the most well known are those of the Duralumin type, containing copper, magnesium and manganese. It is notewhorthy, therefore, that this book should be concerned primarily with the heat-treatment of Duralumin.

The Duralumin alloys, and others of similar type which are designed to conform to similar standard specifications, may be regarded as the standard heat-treated aluminium alloys for structural and aircraft work. In the fully heat-treated condition they combine the strength of mild steel with one-third the weight and have good ductility, permitting reasonable forming. The desirable properties are dependent upon heat-treatment, and this book has been prepared for engineers to assist them in obtaining the desired properties and to facilitate the use of Duralumin.

The author gives a very valuable detailed consideration of the various aspects of heat-treatment, and deals with some of the more practical points with regard to the operation of many of the processes. The work is presented in a lucid and readily understood form; it is practical, and should prove invaluable to all users and potential users of these heat-treatable aluminium alloys.

By P. L. TEED, M.I.M.M.; published by Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C. 2. Price, 12/6.

The Mechanical Testing of Metals and Alloys

THERE are many books which deal with the testing of metals; in this book, however, the author couples descriptions of modern testing equipment with its mode of use, and incorporates in a practical way the theory underlying present-day developments in the testing of metals. Only such types of testing equipment are described as may be found in modern works, testing rooms and laboratories, and an attempt has been made to keep within the range of tests already standardised by the British Standards Institution.

In modern engineering the question of the best distribution of the material to give the greatest strength is of vital importance, because of the increasing tendency to reduce the dimensions of a structure as much as possible, consistent with safety. It is for this reason that the testing of materials is growing in importance, since it provides the designer with information that enables him to use materials to the best advantage. Apart from the designer, however, materials must be tested to ensure that they may be relied upon to reach a certain defined standard; thus, testing in one form or another has become indispensable in modern engineering.

This useful book presents valuable information on the testing of metals used in engineering, and it will be found especially useful to those whose work brings them into close touch with mechanical testing. The information is presented in a lucid form, the book is adequately indexed, and generally will be found to be particularly valuable to students of strength of materials.

By P. FIELD FOSTER, B.Sc., A.M.I.Mech.E.; published by Sir Isaac Pitman and Sons, Ltd., London. Price, 15/- net.

Special Cast Irons

Alloy additions and new foundry technique have produced special cast irons which differ from the ordinary run of cast irons, both of which were discussed by Mr. J. G. Pearce, Director of the British Cast Iron Research Association, in a recent lecture before the Midland Metallurgical Societies, a summary of which is given in this article.

THE older method of distinguishing between cast irons by the terms grey, white and mottled is losing force, and it is now becoming more usual to refer to them as austenitic, pearlitic, cementitic, etc. Pure iron consists of grains or crystals, which have been distorted by the pressure between the grains during cooling from the molten condition; but if a little carbon is introduced into the iron, carbide is formed as thin laminations, with thin laminations of iron or ferrite to form pearlite, and if the carbon is increased to about 0·80% a pearlitic structure is formed, which for practical purposes behaves as a single material in spite of its duplex structure.

The dividing line between iron and steel is quite readily drawn, but not in terms of composition or method of production; the difference is readily distinguishable by the microscope, which shows in what manner the carbon is present. If there is any free graphite, the material is called cast iron; but cast iron also contains greater percentages of silicon, sulphur and phosphorus than steel, and also often more manganese. The task of the ironfounder is so to adjust the composition of an iron-carbon alloy as to obtain a machinable material, and the main factor which does that is silicon. Excess silicon gives a material graphitic in character, so that an iron with a carbon content of 3·6% may have only 0·50% in the combined state, and the remainder occurring as free graphite.

Modern cast irons are now possible, because of better metallurgical control, to give the best structural form, that is, an all-pearlitic structure. A pearlitic iron is not necessarily sound, but great advances have been made, and a pearlitic matrix, interspersed with graphite and phosphide, is the structure obtained in a modern cast iron. The usual characteristics of quality are determined by its strength. Any iron which has a tensile strength of 15 tons per sq. in. or upwards can be regarded as special iron. Above 15 tons per sq. in. were irons giving up to 22 tons per sq. in., and higher figures can be, and are, obtained in straight cast irons.

Among the early irons, termed high-duty irons, was the Lanz or Perlit iron, made in a mould heated to a temperature to suit the composition of the metal. Early attempts to use steel mixture, melted in the cupola, produced irons of a tensile strength of 20 to 22 tons per sq. in. These special irons did not involve large changes in technique, except the hot mould irons. There are, however, two directions in which the special irons produced to-day differ from the ordinary run of cast irons—alloy additions and new foundry technique.

Alloy Additions

Generally, the alloy additions are nickel or copper, which are graphitisers, and molybdenum or chromium, which are carbide formers and hardeners. On account of their graphitising effect, nickel and copper enables the percentage of silicon to be reduced, and silicon is pronounced in its embrittling effect. If 15% or 16% of silicon is included in the iron the resulting material will be hard and brittle, and that effect would naturally be lowered by any element which allowed the silicon to be reduced. Where these additions are used to give a pearlitic iron, the refinement of graphite and of grain size both contribute to the strength of the resulting iron. Nickel and copper have the effect of making the iron pearlitic over a wide range of section, so that there is then less variation between thick and thin sections. The relative softening of those elements, compared with silicon, is known, so that if an alloy is obtained which has the same graphitising effect as a straight mixture, the net chilling or graphitising effect of a series of additions are readily found.

Nickel, for example, has about one-third the effect of silicon, and chromium is about 1·2 times stronger than silicon in the opposite direction. Molybdenum and copper are about one-third as strong as silicon, the former hardening and the latter softening the material. Nickel and chromium, or nickel and molybdenum, can therefore be adjusted to maintain a standard silicon content. Nickel, unlike silicon, toughens rather than embrittles the matrix. For ordinary iron, additions of 1% or 2% of nickel are added. Chromium is a very strong carbide former, but it is not considered wise to add more than 0·25% or 0·50%. Copper graphitises like nickel, and molybdenum is also a very pronounced carbide former. The greying effect, however, represents only one of four or five effects which have to be considered. Nickel is perhaps the most important of the alloying elements, because it is the only metal which enables all the structural variations of cast iron to be obtained—namely, pearlitic, martensitic and austenitic.

With regard to alterations in technique the process used is generally called inoculation, because it involves additions to the ladle of a graphitiser or a material which is supposed to invoke graphite germs in the melt. In 1929 it was shown that superheating refined the graphite size and produced a better iron. It was thought that cupola melting gave no time to produce the graphite particles in the metal, and that their size and distribution depended upon the growth of certain nuclei. That theory has now been abandoned. Now, the iron is melted so low in silicon that it would be a white iron in the ordinary way, but in the ladle a graphitiser is added, in a finely divided form, in proportions of 1—200, or 1—400 parts. One of the best known of these inoculated irons is termed Meehanite; there the addition is calcium silicide. In the iron known as Ni-Tensyl, the additions are ferro-silicon with nickel-F shot.

Ladle additions may be added to deoxidise an iron, but inoculation is ladle additions to white iron to produce the strongest cast-iron made, which would give about 25 tons per sq. in. tensile on a cast material, and these figures can be pushed up by heat treatment. Heat-treatment is undertaken in order to relieve casting stresses, to soften the iron for machining, and to produce iron of more uniform properties. For relieving stresses the temperatures are 450° to 600° C., with slow heating and slow cooling. This treatment will not alter the properties, because it does not alter the structure. For softening for machining purposes, it is necessary to get well above the critical point so that the graphite is dissolved and re-formed afterwards. By this means the pearlite is transformed into ferrite.

Trouble with Light Castings

A commercial trouble with light castings is hard spots, which can be caused by damp moulds. They are not easy to deal with, but 1½ hours' treatment at 850° C. should suffice. Heat-treatment proper—that is, quenching and tempering—can be applied to cast iron as with steel, and here mass and composition come into play. The usual procedure to adopt is to heat above the critical point, quench in oil, and temper in the ordinary way. In dealing with these irons at elevated temperatures there is little change until 450° or 500° C. has been reached. All these

irons expand thermally, but at about 740° C. a critical point is reached at which the pearlite changes to austenite, and there is then a very slight contraction in volume. On cooling the process is reversed, and the graphite is deposited again at a somewhat lower temperature, and the amount is greater, so that the metal is partially graphitised and gives, in the cold state, a slight increase in volume; in other words, there is the phenomenon known as the growth of cast iron. The higher the graphitising element the greater will the change be.

Austenite Iron

The production of austenitic iron has assumed large proportions in recent years. Austenite is of course the condition assumed by the iron above the change-point. This iron, if it could be made in the cold state, would be very useful, as it would not have to go through any change. Nickel reduces the temperature of the critical point, and is used in all austenitic irons. These irons are more corrosion-resistant and ductile than grey cast iron, as well as more heat-resistant, and are non-magnetic. Irons patented as Nomag, Ni-resist and Nicro-silal are three types. Silal is a special iron high in silicon and low in carbon. It is rather brittle, but its structure makes it very stable for certain heat-resisting applications.

Formation of Graphite

A special iron, which is not yet commercially available, has resulted from some work by Dr. Norbury and Mr. Morgan, and has caused the revision of ideas as to how graphite is formed. It is now thought it owes its form to non-metallic inclusions. A small quantity of titanium has been added, and the melt treated with carbon-dioxide gas; it was found that the graphite changed from coarse to very fine. It was supposed that slag particles in the melt caused growth of coarse graphite flakes, now a reduction can be obtained in the size of the flakes in comparatively high-carbon material. It is suggested that the titanium, by means of the gas treatment, and in the presence of certain non-metallic inclusions, prevented the inclusions from acting on the metal in the ordinary way. The effect of this is not to leave the inclusions out, but to allow the metal to solidify without any effect from these inclusions. There is an improvement in properties, and the metal can be heat-treated.

Use of Special Irons

The use of special irons in general results in the fact that under conditions of temperature or alternating stress they show less reduction in mechanical tests than do many of the steels. The most recent applications of special irons are automobile crankshafts, brake drums, etc., but to successfully produce these irons there must be an up-to-date laboratory, close control through every stage of manufacture, including furnaces, moulding, sand preparation, etc. The cupola is still used for the production of many of these irons, but there is a growing tendency to use other types of furnace, and those which were most capable of handling these materials are the rotary and electric furnaces. The rotary, pulverised fuel and oil-fired furnaces are well known. The two types of electric furnace most favoured are the direct arc and the rocking arc types.

The U.S.S.R. Second Five-year Plan and its Fulfilment

By a Special Correspondent

In all branches of industrial activity remarkable progress has been made in the U.S.S.R., and in view of the change effected in this country during the last few years this review of the development of the second five-year plan gives a brief outline of the progress achieved.

THE early years of the first five-year plan laid the foundations of national economy in the U.S.S.R. The industrialisation carried out under that plan made possible the subsequent achievements, such as the conversion of agriculture from a primitive system of small holdings into a system of large-scale farms, cultivated on a collective basis and using the most up-to-date technique in cultivation. The economic aim of the second five-year plan was so to reconstruct the entire national economy as to create a completely new modern technical basis for all its branches. The plan, too, provided for a rapid improvement in the standards of living of workers and farmers, an increase in their real earnings and a twofold or threefold increase in their level of consumption.

The extent to which all these objectives have been attained may be judged from the following brief account of the fulfilment of the second five-year plan: The progress made is reflected in the growth of the national income. At the end of the first five-year plan (1932), the national income of the U.S.S.R. equalled 45,500 million roubles; in 1933 it was 48,500 million roubles; in 1934, 55,800 million roubles; in 1935, 65,700 million roubles; in 1936 it is estimated to reach 83,100 million roubles.

During the period of the first and second five-year plans, the U.S.S.R. invested vast sums for construction purposes. Capital investments during the first five-year plan amounted to 50,000 million roubles, and during the four years that have passed of the second five-year plan to 100,000 million roubles. The investment of these colossal sums has made it possible to renew all the basic fixed capital of the national economy—in industry, transport, agriculture, communications, etc. Whereas at the end of the first five-year plan the fixed capital of large-scale industry was valued at 21,600 million roubles, at the beginning of 1936 it was valued at 37,500 million roubles. During this period numerous new enterprises were established, equipped with the most modern equipment. They included the Dnieper Hydro-Electric Power Station, the Magnitogorsk and Kuznetsk Metallurgical Works, the Stalingrad, Kharkov and Chelyabinsk Tractor plants, the Stalin Automobile Works in Moscow, the Molotov Automobile Works in Gorky, the Kramatorsk and Ural heavy engineering plants, the huge chemical combine of Stalinogorsk, synthetic rubber plants, etc.—all of which laid the foundations for a further industrialisation of the country.

Provisions were made under the second five-year plan for the mechanisation of production processes which required a large amount of labour power. In the coal industry in 1936, the proportion of coal produced by mechanical methods was 87·7% of the entire output; while peat extraction was 80% mechanised. In the iron and steel industry in 1935, 53·5% of the output of pig iron was obtained from mechanised furnaces. It can be said that the U.S.S.R. is now technically and economically independent of other countries. In respect of coal, oil, iron and manganese ores, zinc, aluminium, super-

phosphates, cotton, chromite, tractors and other products, home production is able to meet requirements to the extent of 100%.

In 1936 the U.S.S.R. claim to have attained first place in Europe in volume of industrial output, having surpassed the highest level of production of other countries before the crisis of 1929 in power, oil, iron and manganese ores, iron and steel, rolled metals, superphosphates, lorries, tractors, harvesters and other agricultural machinery, railway carriages, tools, sugar, soap, cotton, etc.

The new industrial enterprises built during the second five-year plan and the mastery of new technical processes, have resulted in a continuous increase in the rate of industrial development. In 1933 the aggregate industrial output increased by 6·2% over that of the preceding year; in 1934 by 18·7%; in 1935 by 20·7%, and during the first nine months of 1936 by 33·7%. Some branches of industry have already more than fulfilled the objectives of the second five-year plan. This applies to such industries as engineering, motor-lorries, tractors, harvesters, bicycles, glass, iron, steel and rolled metals.

The production of electric power in the U.S.S.R. in 1936 reached 32,000 million kilowatt-hours, which is 6·7% more than was estimated for this year in the second five-year plan. In 1932 the total output of electric power was 13,500 million kilowatt-hours. The output of coal in 1936 was about 135 million tons, that is, 8 million tons more than was estimated for this year under the plan. The output of oil this year reached 30 million tons; pig iron, 14·5 million tons; steel, 16 million tons; rolled metal, 12·2 million tons. In the engineering industry the progress made in 1936 was not only in respect of quantity; the production of many new types of machines was mastered, which are being turned out for the different branches of the national economy. During the period of the second five-year plan the production of electric motors was organised, as also were Diesel-electric locomotives, trolley-buses, flax scutchers, drums for high-pressure boilers, turbines of 50,000 k.w. capacity, paper-making machines, etc.

During the first three years of the second five-year plan the productivity of labour in heavy industry increased by 56·4%. The plan for 1936 estimated an increase in labour productivity of 23%, but the actual increase during the first seven months of the year was 28·3%. This is largely attributed to the growth of the Stakhanov movement. Side by side with increased labour productivity, an increasing number of workers were absorbed in industry; the number so absorbed during the first three years of the second five-year plan being 900,000. Special attention has been paid during this period to industrial development on the borderlands of the Soviet Union, in the national minority republics. This applies specially to the Republics of Kazakh, Uzbek, Turkmenian and Tajik.

A great expansion has taken place in the industries producing goods for consumption. Agriculture has advanced rapidly, and to-day, there are 249,100 collective farms, varying in acreage from 600–8,000 acres; 80% of these collective farms were served this year by the machine and tractor stations. In 1935, the grain crop was 30% higher than in 1932, and in 1936 the yield was higher still.

The network of railways throughout the country has been considerably extended. The construction was completed of the Moscow-Donetz Basin and Rubtsovka-Kamenogorsk trunk lines, a new line was opened from Karaganda to Balkash, and the Moscow-Vladivostok trunk line has been turned into a first-class transcontinental route. The development of the engineering industry assures the fulfilment of the plans for the technical reconstruction of the railways. In 1936 the output of powerful locomotives comprised 500 of the SO model, 675 of the FD, 75 of the JS, and other models. Soviet industry also supplied the railways with 800,000 new freight cars, including large four-axle cars, cars with automatic brakes and automatic couplings. The second five-year plan estimated an average daily loading of 79,000 freight cars for 1937, but the average daily loading had already reached 86,600 cars in 1936. Investments in railway transport under the first five-year plan amounted to 6,400 million roubles. During the four years that have passed of the second five-year plan, a sum of 14,000 million roubles has been invested in transport.

In regard to water transport, mention must be made of the two huge waterways constructed during the second five-year plan—namely, the White Sea-Baltic Canal and the Moscow-Volga Canal. The first has been in operation for some time, and the second is to be put into operation within the next few months. The volume of freight carried by river has increased from 46·9 million tons in 1932 to 75·6 million tons in 1936.

Almost every branch of the national economy has not only attained the objectives of the second five-year plan, but has gone considerably beyond. All the enterprises under the control of the Heavy Industry completed the five-year programme last year, that is to say, in four years, while by 1937 (the last year of the plan), all the concerns in the Food Industry will have over-fulfilled their programmes by 40–50%.

The provisions in the plan relating to improvement in the standards of living of the people have been no less sucessfully fulfilled. During the period 1929–36 the average wages of workers and employees have increased threefold. The number of workers and employees has increased from 11·6 million in 1928 to 25 million in 1936. All the able-bodied members of the adult population have been absorbed in production, a fact, which in itself, makes for prosperity.

British Industries Fair

(*Continued from page* 127.)

In metal finishing, a machine is exhibited which automatically polishes hub-cap covers, lids and articles of similar shapes, designed for dealing with stainless steel components. The machine comprises a horizontal rotating indexing table, fitted with five rotating chucks to carry the articles to be polished. Three totally enclosed polishing motors operate the mops, the motors being movable through an angle of 45°. The motors operate off three-phase, 50-cycle, 400-volt supply. Movements are included for horizontal, vertical and cross adjustments. The polishing motors and the motor operating the revolving and indexing mechanism of the table are controlled from a conveniently situated push-button control station. Automatically operated devices are fitted for feeding the polishing composition to the mops, and for increasing the pressure of the polishing mops.

Two centreless polishing machines shown deal with small tubes and a large variety of circular profile articles. Tubes are fed by a special magazine attachment, and circular articles are carried on chucks which are rotated by a profiled feed-wheel, between which and the mop rests the article to be polished. Barrel shapes are handled by means of a reciprocating attachment, the movement preventing linear markings on the work. Annular articles, as cycle rims and lamp rings, can be polished by means of an attachment which carries and revolves the articles between a grooved wheel and adjustable guide-wheels. Rods and tubes of various lengths and diameters may be polished on these machines.

Developments of Incandescent Heat Co., Ltd.

During the past few months the Incandescent Heat Co., Ltd., have carried out considerable extensions to their already well-equipped works at Smethwick, Birmingham. In addition to extensions to the works, the drawing and commercial office accommodation has been increased. Recent contracts secured include installations for Government departments, automobile manufacturers, and several large iron and steel works. Further extensions are now being made to the works, and production is being speeded up to meet the increased demand.

Copper Alloy Cylinder Heads

A PROGRESS report on certain comparatively new uses of copper, some of which are still in the development stage formed a part o fan interesting and informative paper recently presented before The Institution of Automobile Engineers, by N. P. C. Neave, on the subject of "Copper and Its Alloys in Automobile Design." Particular interest centred on the author's reference to copper-alloy cylinder heads. As is well known copper occupies the same high position relative to other metals with regard to thermal as to electrical conductivity, and for most copper alloys, percentage values of thermal conductivity at normal temperatures agree approximately with percentage values of electrical conductivity. At elevated temperatures the electrical conductivity of H.C. copper falls, whereas its thermal conductivity is little affected, and the copper alloys, such as bronzes, show in general an enhanced thermal conductivity at temperatures of the order of 300° C. The use of cylinder heads of a suitable copper alloy with high thermal conductivity has been considered, but, until recently, such an alloy has not been easy to try out, owing to fabrication difficulties. Developments have occurred which render possible the manufacture of high-conductivity copper alloy cylinder heads.

Copper of high purity, as cast, has probably an insufficiently high limit of proportionality to withstand the pressure of the cylinder-head holding down bolts without constant retightening, and the problem is to select an alloy giving a limit of proportionality of about 10 tons per sq. in. as cast, and tensile strength over 20 tons per sq. in., while retaining 80% conductivity or higher, and presenting no insuperable casting difficulties. After consideration of the opper alloys available, the choice appears to narrow down at present to copper containing 0·4% to 0·5% of chromium, in the precipitation hardened condition. These alloys, if carefully prepared, may be expected to possess thermal conductivities of the order of 0·7 to 0·8 cgs. units at working temperatures. Chromium-copper alloys in wrought forms are already fairly widely used, and a considerable patent literature exits. These alloys have good high temperature properties, and are now being employed in certain cases for spot welder tips.

A brief summary of one process is given by the author which has been suitable for making chromium-copper cylinder-head castings. Copper ingot or cathode of the highest purity, as for electrical purposes, should be employed, and care taken that the crucible or furnace walls are free from pollution by iron or any of the other elements likely to spoil the conductivity of the metal. If iron stirring rods are used, it is suggested that they should be coated with a refractory, with a view to keeping the iron content below 0·05%. The molten metal may be protected by a charcoal cover, and deoxidation to eliminate the known oxygen content may conveniently be effected by the addition of, say, 0·2% cadmium alloyed with 2% of its weight of metallic sodium. When deoxidation is complete, about 0·5% of chromium may be added in the form of 10% chromium-copper master "alloy" previously prepared in an electric furnace. The metal should be poured quite hot, say, at about 1200° C. Green sand moulds may be employed with a coarse sand, such as Pickering, but to correct the superficial effects of porosity of this sand, and to give a good finish to the casting, a liberal coating of graphite should be applied to moulds and cores, which should also be made of a friable sand. The metal experiences severe shrinkage, and generous risers should be provided, as in steel-casting practice. As soon as possible after solidification, the castings should be knocked out, as at this stage the metal is tender, and tearing may occur at flanges and corners, unless unrestricted thermal contraction is permitted. Castings for water-cooled single-cylinder overhead-valve heads made by this method have been tested, while multi-cylinder overhead-valve heads have since been cast experimentally.

Catalogues and Other Publications

General Electric Co., has just issued a new catalogue of wires and cables which contains particulars of the new cable standards that were introduced by the Cable Makers' Association on January 1, 1937, and represent the result of the continuous co-operative research and experimental work of C.M.A. members. The new standards provide for two types only, which are sold under the trade marks C.M.A. and Nonazo, in place of the four types sold in the past. A folder is also included, which gives tables of current ratings of cables and cords, in a handy form for the pocket. Copies are available from General Electric Co., Ltd., Magnet House, Kingsway, London, W.C. 2.

The Butterley Company have recently issued an excellent booklet which traces the history of the firm and gives detailed information of its products. Founded in 1790 to operate coal workings the Butterley Ironworks were erected two years later. To-day the Company has nearly 10,000 employees engaged in a variety of widespread activities, and this booklet describes the present scope of the Company and the ways in which it caters for the modern needs in the development of civil engineering. The booklet is wonderfully produced and will be found both interesting and informative. Copies may be obtained from Butterley Ironworks, Derby, England.

The current issue of *The Nickel Bulletin* contains an article dealing with one of the problems confronting the automobile engineer—*viz.*, automobile cylinder wear. Mr. J. F. Paige discusses aluminium-alloy pistons for heavy oil engines, and two pages are given to the properties of nickel. In addition the issue contains other features of value. Copies may be obtained from the Bureau of Information on Nickel, The Mond Nickel Co., Ltd., Thames House, Millbank, London, S.W. 1.

The second issue of *Alloy Metals Review* recently published, contains a very informative article on alloy constructional steels by Mr. J. A. Jones; the author points out that there is an increasing demand for steels for constructional purposes which possess higher tensile strength, accompanied by adequate ductility and toughness and direct attention to a number of low-alloy steels which fulfil these requirements. This issue also refers to a new tungsten-carbide cutting tool; molybdenum stainless steel; tungsten, vanadium and molybdenum steels for punches and dies; tungsten and molybdenum in the manufacture of colours; and a number of abstracts. Copies may be obtained from High Speed Steel Alloys, Ltd., Widnes, Lancashire, England.

Ether, Ltd., Tyburn Road, Erdington, Birmingham, have sent us a four-page leaflet giving technical notes on the measurement of casting temperatures of molten metal. Even under the best conditions molten-metal temperatures are not easily measured with accuracy and these notes will be helpful in obtaining good results.

Foundry Services, Ltd., 285, Long Acre, Nechells, Birmingham, 7, have sent us a copy of their issue No. 23 of "Foundry Practice" and also "Foseco News" No. 1. The former contains information on British melting furnaces; uses for aluminium alloys, and also information given in "The Chemist's Corner" which is a regular feature. "Foseco News" deals briefly with all new developments of Foseco products, particular mention being made of a new die dressing, recovery of metal from turnings, a cleanser for tin and tin-base alloys, etc. Copies of these may be obtained on application to the above address.

Uddeholm General Agencies Ltd. have sent us three brochures which deal with the works and products of The Uddeholm Co. Ltd., Sweden. One concerns the various qualities of cold-rolled steel strip manufactured at the Munkfors Works; a second describes a number of standard qualities of stainless, acid- and heat-resitant steels, developed by this company, which form a complete range in respect of their properties and applications; while a third gives a historical account of the works. Each is admirably prepared, being both interesting and informative. Copies may be obtained from Uddeholm General Agencies Ltd., 111, New Street, Birmingham, 2.

Business Notes and News

Davy Brothers and United Engineering

As a result of a fusion of interests between Davy Bros., Ltd., of Sheffield and the United Engineering and Foundry Company, of Pittsburg, U.S.A., the former have obtained the sole right to manufacture and sell all the products of the American company in the British Empire, with the exception of Canada. In return for this, the United Engineering and Foundry Company will have the right to manufacture and sell in North America the speciality products upon which Davy Bros. have built up their reputation. Mr. K. C. Gardner, vice-president of the United Engineering and Foundry Co., has joined the Board of Davy Bros., Ltd., and it is understood that as and when the necessary formalities are completed the company's name will be changed to "Davy and United Engineering Co., Ltd."

The United Engineering and Foundry Co. is well known for the manufacture of rolling-mill plant in the United States, particularly in the development of the four-high hot- and cold-strip mills, and in the manufacture of "Unefco" rolls. The large extensions of Davy Bros. works at Sheffield are now approaching completion, and it is the Board's aim to provide an organisation within the country capable of furnishing the highest grade and efficient service to the British iron and steel industry.

It will be remembered that Davy Bros. recently acquired the old-established business of the British Chilled Roll and Engineering Co., Ltd., of Middlesbrough, and it is intended to extend the works of this company and to bring to bear all the experience of the American company to ensure the production of rolls similar in every respect to those manufactured by the United States.

Symposium on Steelmaking

The Council of the Iron and Steel Institute announce that arrangements are in progress for the holding of a Symposium on Steelmaking, in connection with the Annual Meeting in May, 1938.

The Symposium will be designed to provide opportunities for the discussion of the practical and theoretical aspects of steelmaking by all processes, but with particular attention to the acid and basic open-hearth processes. Papers will be invited on: The design and layout of melting shops; furnace design and operation, including heat economy, etc.; steel manufacture, including casting, slag utilisation, steelworks refractories, etc.; metallurgical reactions, including the physical chemistry of steelmaking, the constitution of slags, non-metallic inclusions, segregation, etc.

Further information will be issued in due course.

Ebbw Vale Steelworks Plant

In addition to the orders, mentioned in a previous issue, which have been placed in connection with the reconstruction scheme by Messrs. Richard Thomas and Co., Ltd., at Ebbw Vale, which includes the installation of a complete mill for rolling hot- and cold-strip and tinplate, an important section of the plant will be manufactured by the General Electric Co., Ltd.

At their Fraser and Chalmers Engineering Works the G.E.C. will produce approximately 3,000 tons of mechanical plant to drawings supplied by the United Engineering Co., of America. This machinery will consist of the cold-rolling section of the scheme, which includes three skin-pass mills (comprising six housings, each of 56 tons), shearing line, and a number of coilers, de-coilers, shears, tensioning device, and all auxiliary apparatus in connection with the manufacture of cold-roll sheet and tinplate.

The electrical equipment, which is being manufactured at the G.E.C. Witton Engineering Works, Birmingham, includes the motors for the cold-strip mill, of which the most important are three direct-current machines, each of 1,500-h.p. output. These, together with a 400-h.p. d.c. motor, are supplied from a 3,500-kw. synchronous Ward-Leonard set. In addition, the electrical plant to be built at Witton includes a number of motors for the continuous hot-strip mill, motor control gear, three 2,000-kva. transformers, two 11,000-volt remote electrically-controlled metal-clad switchboards—one of 17 panels, and the other of 10 panels,—and over 100 direct-current reversible steelworks motors for driving mill auxiliaries.

I.C.I. Metals Making Aluminium Alloy

I.C.I. Metals, Ltd., announce that they are manufacturing aluminium alloy in sheet and strip. They have taken this step in order to meet the increasing demand, particularly from the air, rail and road transport industries for this material.

They are on the Air Ministry list of approved suppliers, and their material complies with the latest B.S.I. and D.T.D. specifications. Their entry into the aluminium-alloy field adds to an already very wide range of non-ferrous metal products.

Obsolete Shipping and Scrap Steel Shortage

The scrap-and-build scheme, which is in operation in connection with cargo vessels, is having a considerable influence on the rise in price of scrap steel. The high prices ruling for obsolete tonnages are inducing foreign companies to pay prices for any ships available under the scheme at much higher figures than are offered by British firms. Some ten British ships were reported in January to have been sold to foreign shipbreakers in this way. As a result of this scrapping new orders for vessels have been placed, but there is a disquieting factor in the present shortage of steel, and there appears a risk of a steel famine.

Steel production in Britain is not yet able to meet the demands of industry, and the shortage of scrap steel will adversely affect any rapid expansion of production. Obsolete shipping forms a very useful source of this commodity, and their disposal abroad presents a situation in which benefits accrue to the owners in order to supply the chief steel-exporting countries abroad with an important raw material. Although imports of iron and steel have increased greatly above that allowed under the cartel agreement, the rapid expansion of demand abroad has reduced available Continental steel which can be imported here.

Electrically Heated Salt-Bath Furnaces

Messrs. Birmingham Electric Furnaces, Ltd., have acquired, by an agreement with G. Siebert, G.M.B.H., sole manufacturing and patent rights in the well-known Kærcher electrically-heated salt-baths for Great Britain and the British Empire (except Canada).

These equipments are widely used for the heat-treatment of aluminium alloys and employ easily replaceable internal heating elements of special design giving exceptional uniformity and rapidity of heating, long life and complete safety in operation.

Some Recent Contracts

As a result of negotiations which have been successfully concluded between the Turkish Government and Messrs. H. A. Brassert and Co., British steel and engineering firms will benefit to the extent of about £3,000,000. The contracts, which will be spread over eight firms, are for steel works, and are part of Turkey's second five-year plan. Sir Alexander Gibb and Partners, consulting engineers, are to supply the technical direction necessary to enable various industrial and public works projects to be carried out.

The second Turkish five-year plan is due to come into operation at the end of this year, and negotiations between British firms and the Turkish Government are now in progress for supplying more equipment. If these materialise a further £5,000,000 is expected to come to this country.

Three new contracts are announced by two Clyde shipyards. Denny Bros., of Dumbarton, has been commissioned to build two 4,000-ton cargo liners for P. Henderson and Co., of Glasgow, and the Nourse Line, Ltd., has instructed Charles Connell and Co., of Scotstoun, Glasgow, to build a motor liner of 9,200 tons deadweight. Six months ago the Scotstoun Yard was without a keel. Work on five vessels is now being commenced. Meadowside Shipyard, formerly operated by D. and W. Henderson, Ltd., and acquired over a year ago by National Shipbuilders Security, Ltd., has been resold to the Clyde Navigation Trust. The shipyard will be used by the Clyde Trust for deep-water berths and shed accommodation.

The General Engineering Co. (Radcliffe), which has for a number of years supplied leading British cable makers with patented machinery, has just secured a large contract for machinery for making electric cables from the Soviet Government.

MARKET PRICES

ALUMINIUM.

98·99% Purity	£100	0	0

ANTIMONY.

English	£77	10	0
Chinese	65	16	0
Crude	36	0	0

BRASS.

Solid Drawn Tubes	lb.	11¼d.
Brazed Tubes	„	13¼d.
Rods Drawn	„	10d.
Wire	„	9¼d.
*Extruded Brass Bars	„	6½d.

COPPER.

Standard Cash	£55	16	0
Electrolytic	60	10	0
Best Selected	60	0	0
Tough	59	10	0
Sheets	87	0	0
Wire Bars	61	5	0
Ingot Bars	61	5	0
Solid Drawn Tubes	lb.	13¼d.	
Brazed Tubes	„	13¼d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	1½
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2-4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL: 4-6% Carbon, scale 7/- per unit	„	22	7	6
NOMINAL: 6-8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL: 8-10% Carbon, scale 7/- per unit	„	21	12	0
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	33	0	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	36	0	0
§Guar. max. 0·5% Carbon, scale 12/6 per unit	„	37	10	0
‡Manganese Metal 97-98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25-50%	„	0	12	8
§ Spiegel, 18-20%	ton	8	0	0
Ferro Silicon— Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	9	0	0
45/50% basis 45%, scale 5/- per unit	„	11	15	0
70/80% basis 75%, scale 7/- per unit	„	16	15	0
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	0	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20-25%	ton	22	0	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—						
S. Wales	£1	10	0	to 1	12	0
Scotland	—			1	8	0
Durham				1	4	6
Furnace Coke—						
Scotland	1	5	0	to 1	6	0
S. Wales	1	4	6	to 1	5	0
Durham	—			1	1	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£78	10	0
*Commercial Ingots	59	10	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 10
*Cored Bars	„	0	1 0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	10	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	13	0	0
Common Bars	9	5	0
Lancashire—			
Crown Bars	10	10	0
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	10	10	0
Marked Bars	13	0	0
Unmarked Bars from	9	7	0
Nut and Bolt Bars £8 17 6 to	9	7	6
Gas Strip	11	7	6
S. Yorks—			
Best Bars	10	15	0
Hoops from	11	7	6

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	10d.
*Cored Bars	„	1/-
†Strip	„	1/1
†Sheet to 10 W.G.	„	1/1½
†Wire	„	1/2½
†Rods	„	1/2
†Tubes	„	1/3⅝
†Castings	„	1/1½

†10% Phos. Cop. £3 above B.S.
†15% Phos. Cop. £5 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£4	18	0
Foundry No. 1	4	10	6
„ No. 3	4	8	0
N.E. Coast—			
Hematite No. 1	4	18	0
Foundry No. 1	4	3	6
„ No. 3	4	1	0
„ No. 4	4	0	0
Silicon Iron	—		
Forge	4	0	0
Midlands—			
N. Staffs Forge No. 4	4	3	0
„ Foundry No. 3	4	6	0
Northants—			
Foundry No. 1	4	6	6
Forge No. 4	4	0	6
Foundry No. 3	4	3	6
Derbyshire Forge	4	3	0
„ Foundry No. 1	4	9	0
„ Foundry No. 3	4	6	0
West Coast Hematite	5	3	6
East „ „	—		

SWEDISH CHARCOAL IRON AND STEEL.

Export pig-iron, maximum percentage of sulphur 0.015, of phosphorus 0.025.
Per English ton Kr. 150

Billets, single welded, over 0.45 Carbon.
Per metric ton Kr. 295-365
Per English ton £15 10 0/£19 0 0

Wire Rods, over 0.45 Carbon.
Per metric ton Kr. 345-395
Per English ton £18 0 0/£20 15 0

Rolled Martin iron, basis price.
Per metric ton Kr. 235-250
Per English ton £12 6 0/£13 0 0

Rolled charcoal iron, finished bars, basis price.
Per metric ton Kr. 330
Per English ton £17 6 0
f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£45	0	0
„ Braziery	42	0	0
„ Wire	—		
Brass	26	0	0
Gun Metal	43	0	0
Zinc	12	10	0
Aluminium Cuttings	74	0	0
Lead	23	10	0
Heavy Steel—			
S. Wales	3	10	0
Scotland	3	2	6
Cleveland	3	5	0
Cast Iron—			
Midlands	2	15	0
S. Wales	3	7	6
Cleveland	3	10	0
Steel Turnings—			
Cleveland	2	5	0
Midlands	2	2	0
Cast Iron Borings—			
Cleveland	1	7	6
Scotland	2	2	6

SPELTER.

G.O.B. Official	—		
Hard	£19	10	0
English	23	15	0
India	19	0	0
Re-melted	20	10	0

STEEL.

Ship, Bridge, and Tank Plates			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „	—		
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ¼ in. to ½ in.	„	3d.
Under ½ in. to ⅛ in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ¼ in.	„	3d.
„ „ ¼ in. × ½ in.	„	1/-

TIN.

Standard Cash	£226	5	0
English	226	5	0
Australian	226	5	0
Eastern	228	17	6

Tin Plates I.C. 20 × 14 box 18/9

ZINC.

English Sheets	£33	10	0
Rods	32	10	0
Battery Plates	—		
Boiler Plates	—		

LEAD.

Soft Foreign	£27	0	0
English	29	0	0

*McKechnie Brothers, Ltd. Feb. 10 †C. Clifford & Son, Ltd., Feb. 10. ‡ Murex Limited, Feb. 10.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse, Feb. 10.